The REFINER AND NATURAL GASOLINE MANUFACTURER

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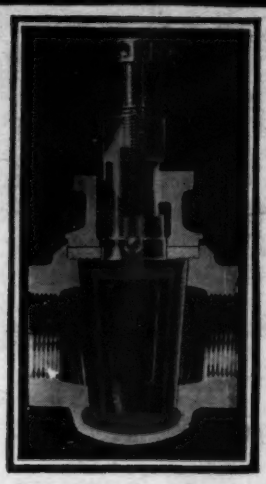
WITHSTAND PRESSURE FAR IN EXCESS OF RATING

NORDSTROM VALVES

Report by CALIFORNIA TESTING LABORATORIES

A Nordstrom semi-steel plug valve, 2½" screwed, 500 pounds working pressure, was recently tested by the California Testing Laboratories. According to the report of test, internal hydrostatic pressure was applied to this Nordstrom Valve with valve in "closed" position. The pressure was increased until a maximum of **1700 pounds per square inch** was reached.

There was no plug or gasket leakage at this pressure!



500# VALVE withstands 1700# pressure test

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THE MONTH IN REVIEW

In the following columns will be found a brief digest of happenings of interest to refiners, with even reference to a rumor or two!

GASOLINE production and supply is to be revealed in more detail in weekly reports of the American Petroleum Institute through inclusion of data on the amount of cracked gasoline produced and stocks of gasoline held at bulk terminals and in water borne transit.

"It is assumed that every refiner in the country that has gasoline to report under either or both of the above heads will co-operate in the compilation and publication of these figures which, when obtained, will be made a part of the present weekly refinery report of the Institute," it was explained in a letter to refiners. "Individual company figures, as is customary, will be held strictly confidential and under no circumstances will they be used for any other purpose than the compilation and publication of consolidated figures.

"No figure whatever are available which would indicate how much gasoline is in storage throughout the country at places other than refineries, and it is an effort to obtain figures for the industry covering that very important factor in the gasoline stocks situation that this request is being made. Figures indicating the production of cracked gasoline are now being published by the Bureau of Mines monthly, but the need of having this information weekly is of great importance to the industry."

In the case of stocks at bulk terminals, report is to be made also on the amount held for the corresponding week a year ago. Bulk terminals are defined as those of not less than 50,000 barrels capacity. The figures on water borne transit will exclude tankers or barges of less than 25,000 barrels capacity.

CRUDE oil production in the United States during May averaged 2,597,700 barrels daily, compared with 2,567,250 barrels in April. The increase was practically all due to production gains in Oklahoma, Kansas and Texas. Total United States crude oil production during May is estimated by the American Petroleum Institute at 80,529,600 barrels. This was a gain over the 77,017,500 barrels produced in April, but the difference in number of days had at least a partial influence in lowering the total output. Developments at Oklahoma City, the Voshell pool in Kansas and the Darst Creek and Refugio fields in Texas were important factors in the increase.

DRILLING of oil and gas wells in the United States in May showed a material increase over the results for April. Well completions* aggregated 1973 during May, against 1702 in April, while new oil production amounted to 765,577 barrels, against 776,024 barrels in April. The decline in new production indicates that the initial yield per well had declined from 758 barrels per well in April to 687 barrels in May. Failures constituted 31 per cent of total well completions in May, against 29 per cent in April. Oklahoma, Kansas, Texas, Gulf Coast, North Louisiana, Arkansas and California, all registered gains in number of wells completed, while the Eastern States showed a material decline.

*Data on Mountain States omitted.

CRUDE price changes during May included reduction on May 1 of all Pennsylvania grades 25 cents per barrel, and advance on May 2 of Corning crude 10 cents per barrel. Eastern states production currently is running around 135,000 barrels daily; a year ago it was 115,000 barrels. Refiners of "pure Pennsylvania" motor oils advertise that it is so good that it does not need to change so often—formerly it was every 500 miles.

OKLAHOMA producers striving to keep crude output of the state down to 600,000 barrels daily and not succeeding, decided on May 12 that the output of Oklahoma City pool should not be increased from its prorated allowance. At the close of the month it was running around 125,000 barrels daily. Only about one fourth of Oklahoma City's wells are flowed each day under proration agreements, the output being restricted by pipe line outlet and orders from conservation officials. Without these restrictions output would be around, possibly exceed, 400,000 barrels daily.

GASOLINE demand has increased 14 per cent during the first quarter of this year.

At the same time gasoline production at refineries, due to rate of processing crude, expansion of distillation equipment and rapid installation of additional cracking facilities, has increased to the point where gasoline stocks are ranging around 50 to 55 millions of barrels.

Concurrent with this condition motor fuel prices are soft, or have at least withstood any tendency toward advance in prices.

Despite the weekly appearance of refinery runs statistics which should have been a major force in guiding the industry toward stabilization of crude through-put in regard to gasoline stocks and their unnecessary accumulation, the industry is not enjoying the healthy condition which it had every right to expect during this period of larger demand.

The fact that weekly American Petroleum Institute refinery runs estimates are including stocks of the major products and their storage by districts, and even segregates the production of cracked gasoline, should be ample guide to refining executives in the industry, who should in turn bring to bear their influence to prevent the operation of their refining facilities at full capacity or at capacity above that which is required to fill current needs.

CONTINENTAL Oil Company and Tide Water Associated Oil Company will not merge, according to President Dan J. Moran of the former organization. The denial followed published rumors that details were being worked out. Basis for the rumors in this connection was obscurely found in ramification of stock ownership in Continental and Tide Water Associated groups. Standard Oil Company of New Jersey had a substantial interest in Continental Oil Company of Maine which was absorbed by Tide Water Associated Oil Company many months ago. J. P. Morgan & Company apparently had control of Marland Oil Company at the time of its merger with Continental Oil Company of the Rocky Mountain area, and now is represented on the board of Continental Oil Company. Coincident

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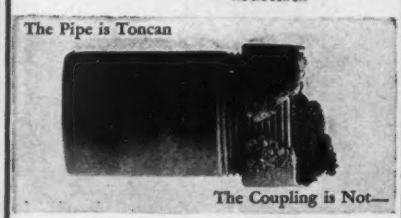

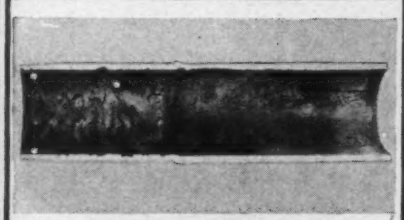

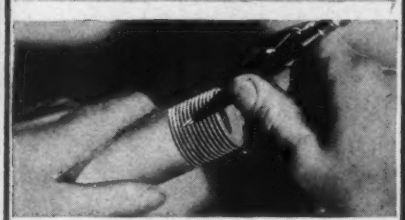

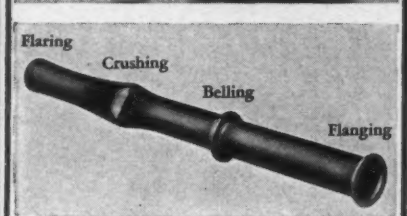

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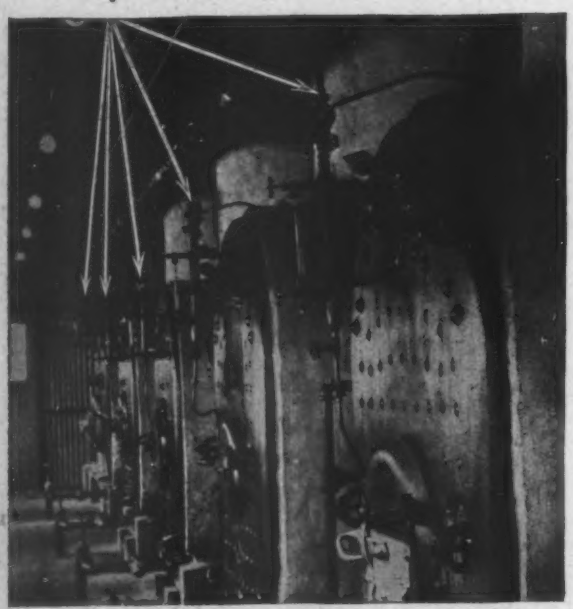

But that isn't all. Here is a letter written by the Superintendent of Plants:

"I am pleased to inform you that we have 15 Campbell Boiler Feed Water Regulators in use in this district and they are taking care of our boiler feed regulation very satisfactorily. In fact they are the only regulators we have tried out that operated positively and lived up to the claims made by the manufacturers."

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Street..... City..... State.....

with denial of the merger rumor, announcement was made that a group of Tide Water Associated Oil Company officials had acquired the stock held by Standard Oil Company of New Jersey in that organization.

*BACK-FIRE of the engine on Mo*tor Tanker Schurchia was the cause assigned for a fire which on May 8 destroyed the ship, a barge, three piers, warehouses, 14 tanks and 200,000 barrels of oil, endangering the entire plant of Gulf Refining Company at Constable Hook, Bayonne, New Jersey. Damage was estimated above $3,000,000, fourteen were seriously and scores slightly hurt. The blaze was spectacular, burning oil from the exploded tanks endangering the near-by town and adjoining properties of Standard Oil Company of New Jersey and Tide Water Oil Company.

*RAILROADS out of the Mid-Con*tinent, facing loss of freight to proposed gasoline lines to the Great Lakes area, are proposing to stop construction of the lines by reductions in freight rates. A conference in Tulsa early in May found executives of the two branches of industry in a deadlock as to agreement. A line under consideration is that of Barnsdall Oil Corporation from Okmulgee northward. E. B. Reeser, president of that concern, and other refinery executives met with representatives of the carriers. It is not likely that freight rate reductions can be made an inducement to halt construction of the lines, as obviously rates would be on a parity for all shippers, while owners of a pipe line would have a distinct advantage over competition if line movement of gasoline is cheaper than rail.

Perhaps some railroads seeking oil freight might be induced to burn fuel oil in their locomotives in return for advantageous routing of refinery products on long hauls.

GULF Oil Corporation through acquisition of Paragon Refining Company secures 350 wholesale and retail outlets in Ohio and Michigan along with the 8000 barrels daily capacity modern refinery at Toledo. Purchase was through Union Trust Company, a Mellon institution in Pittsburgh, the reported price $10,000,000. Paragon Refining Company currently reports dis-

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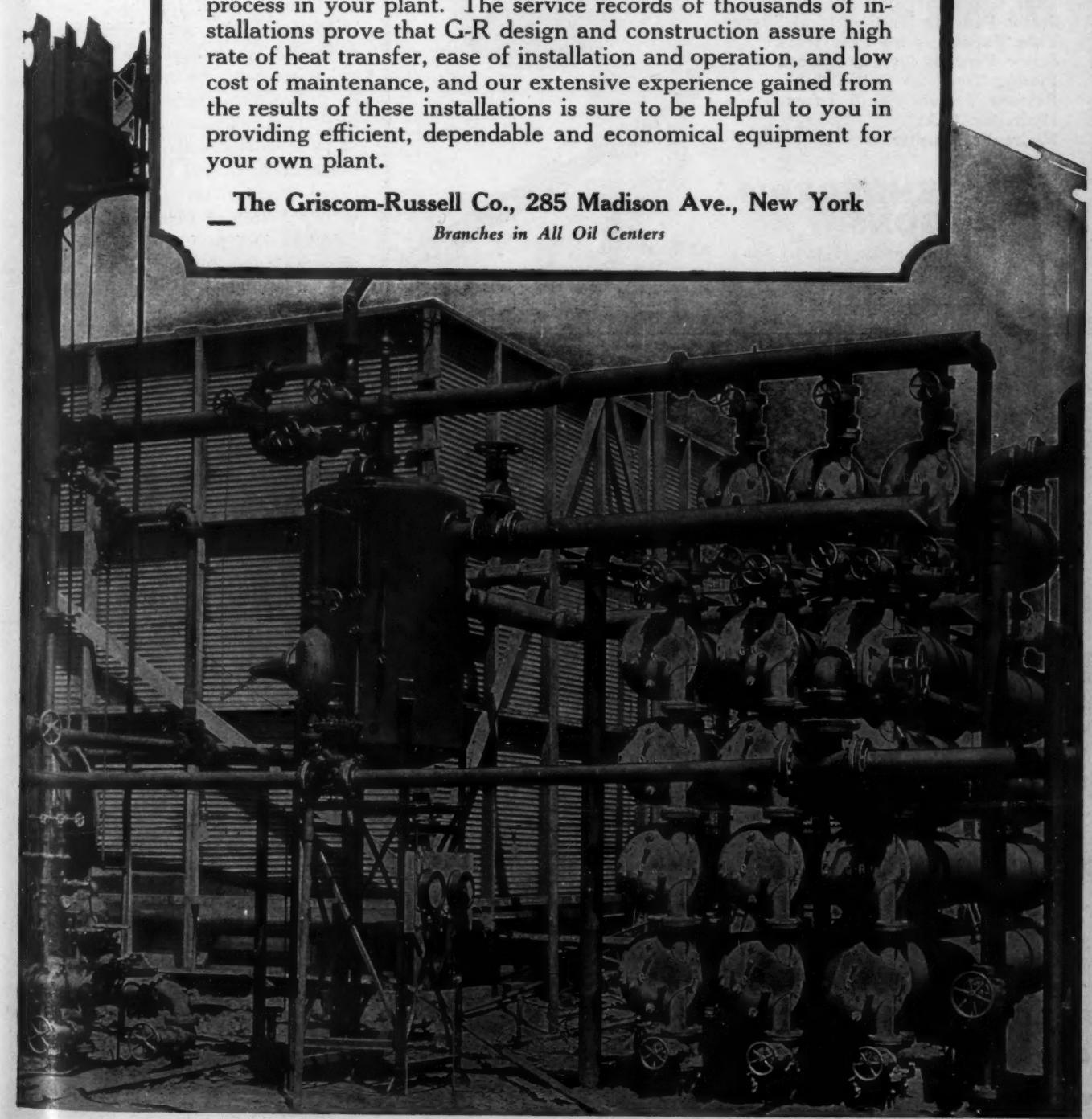
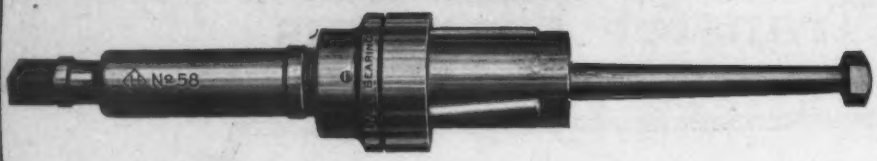


Heavy Duty Expanders for Still Tubes



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tribution in excess of refinery capacity, which lends credence to report that the Toledo plant will be enlarged. Subsidiaries of Paragon Refining Company include Paragon Development Company, a pipe line company operating in Kentucky; Paragon Oil Company, a similar organization in Kansas; Paragon Refining Company of Michigan, and Wayco Oil Corporation of Detroit. Sale does not include cash and accounts receivable nor stock in the Valvoline Company recently acquired by Paragon Oil Company.

PHILLIPS Pipe Line Company (Delaware, one million no-par common) has been chartered for the purpose of building an eight- and 10-inch pipe line from the Texas Panhandle to Kansas and points east. Distance will be 800 to 1000 miles, according to Frank Phillips, president of the company, to cost from 12 to 15 million dollars. The line will handle crude, natural gas gasoline or refinery gasoline as occasion warrants, Phillips Petroleum Company having sufficient production of either of these products to insure success of the project. Heretofore Phillips Petroleum Company, largest producer of natural gasoline, has been making deliveries of that product for delivery in lines with crude oil to the Gulf.

A NEW refinery to be built by Skelly Oil Company is under consideration, although the plan is not yet definite. The preliminary announcement is that a combination skimming and cracking plant will be built near Pampa, Texas, where the company has crude oil reserves. Plans also have been announced for building a new lubricating oil plant at the company's El Dorado, Kansas, plant, as well as other extensive improvements.

Building of the Texas plant will allow Skelly Oil Company to extend its retail marketing territory farther into Oklahoma and into a part of Texas.

STANDARD Oil Company of California reported earnings in 1929 of $46,633,490, an increase of $549,672 over the previous year. This is $3.70 per share and $3.66 for the two years. Net before depreciation, depletion and taxes was over seventy million dollars. The statement reveals that this company, third largest in the industry, is conservative in its inventory figures, car-

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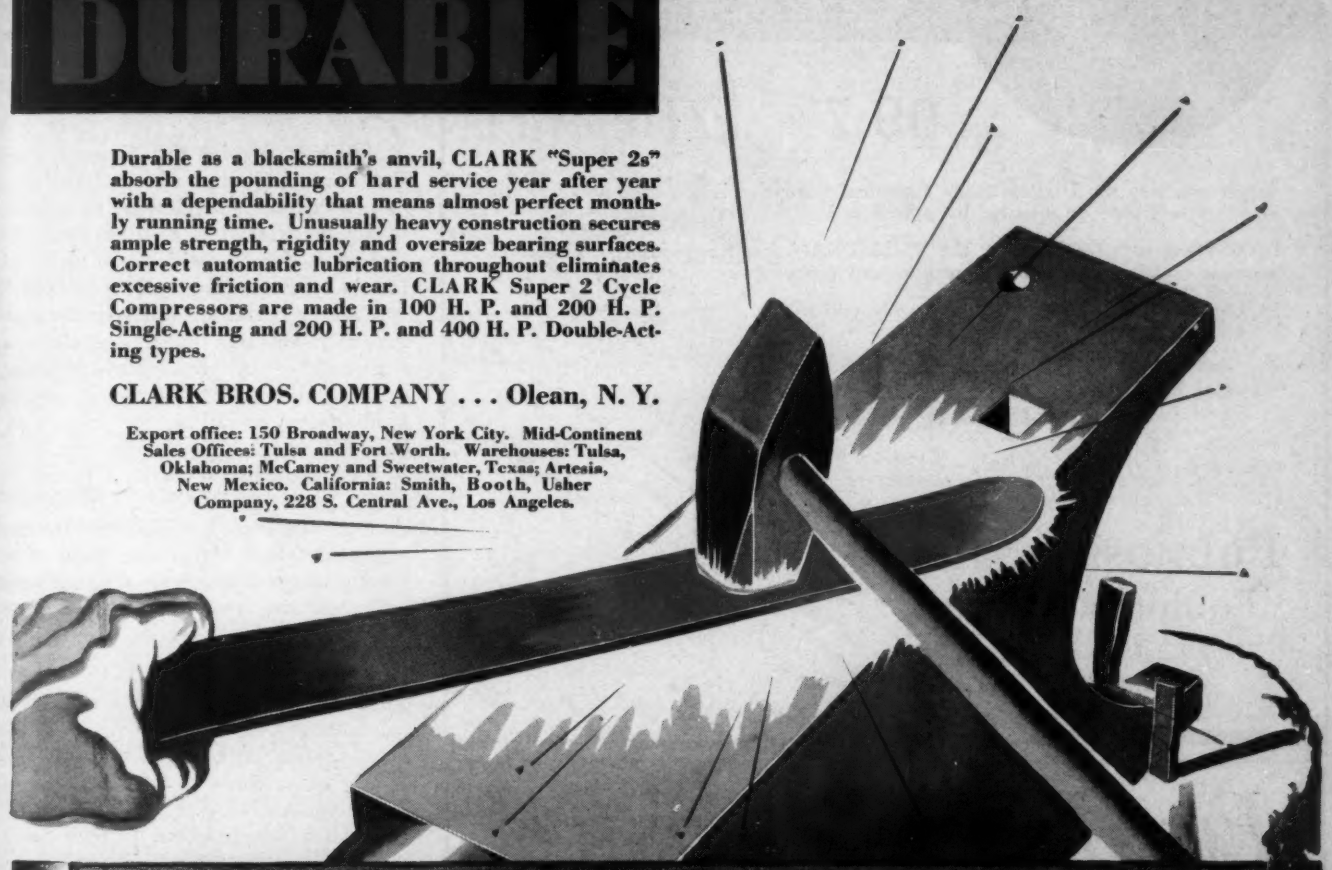

200 H. P. "Super 2s" in the I. T. I. O. Vern gasoline plant at Oklahoma City.

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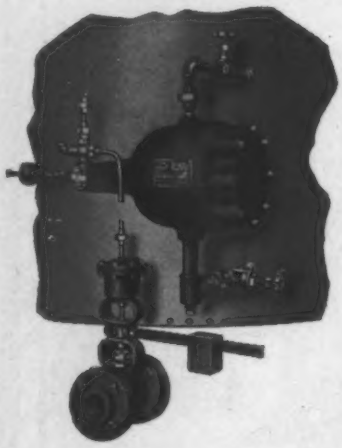
of Liquid Levels in Refining



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rying 6,000 acres in Kettleman Hills at $7.00 per acre, while estimates place the value of these lands at $50,000 to $100,000 per acre; three wells on the property are now producing 9000 barrels of high gravity oil, 250,000 barrels of natural gasoline and 250,000,000 cubic feet of gas. This property is responsible for the company acquiring gas line properties and plans for distribution of natural gas, by pipe and tank car, to the whole of the Pacific Coast.

CITIES Service Oil Company and Standard Oil Company of New Jersey, acting through subsidiaries, have joined in the organization of Paraguana Petroleum Company which will undertake the immediate development of 400,000 acres of potential oil lands in the Paraguana peninsular of Venezuela. Announcement of the project comes through Henry L. Doherty & Company, holding organization for the Cities Service group. Eventually the newly formed company is to pass to control of the Doherty interests. It was said that the land to be exploited is more accessible than Maracaibo Basin fields for the reason that it is not necessary to cross the troublesome Maracaibo bar.

PIERCE Petroleum Corporation passes to Sinclair Consolidated Oil Corporation upon ratification by stockholders of the former of purchase on exchange of stock. Announcement of H. F. Sinclair says that the deal is advantageous to both parties, the Sinclair organization profiting most through extension of market outlet—more than 1500 bulk and retail stations acquired making Sinclair products available in all sections of the United States except the far west, and 183 distributing agencies in Mexico. Refining properties involved include an 8000-barrel refinery at Sand Springs, Oklahoma, and a skimming plant at Tampico. A terminal at Texas City, 400 miles of pipe lines and interest in several thousand acres of prespective oil lands. This marks the passing of one of the oldest oil companies. Organized 75 years ago as John Finlay & Company, successively H. C. Pierce & Company, Waters, Pierce & Company and Waters-Pierce Oil Company, it was 68 per cent Standard Oil Company of New Jersey at the time of the dissolution in 1911. Rockefeller interests disposed of their holdings in 1913.

THE Italian government has now put in force the Royal Decree of February 14, 1930, compelling the addition of certain quantities of nationally produced alcohol to gasoline intended for use as a carburant. The law is designed to enable the Italian wine-growing industry to dispose of its large stocks of unsalable wine.

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and Natural Gasoline Manufacturer

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GRADY TRIPLETT, *Editor* — GEORGE REID, *Associate Editor*

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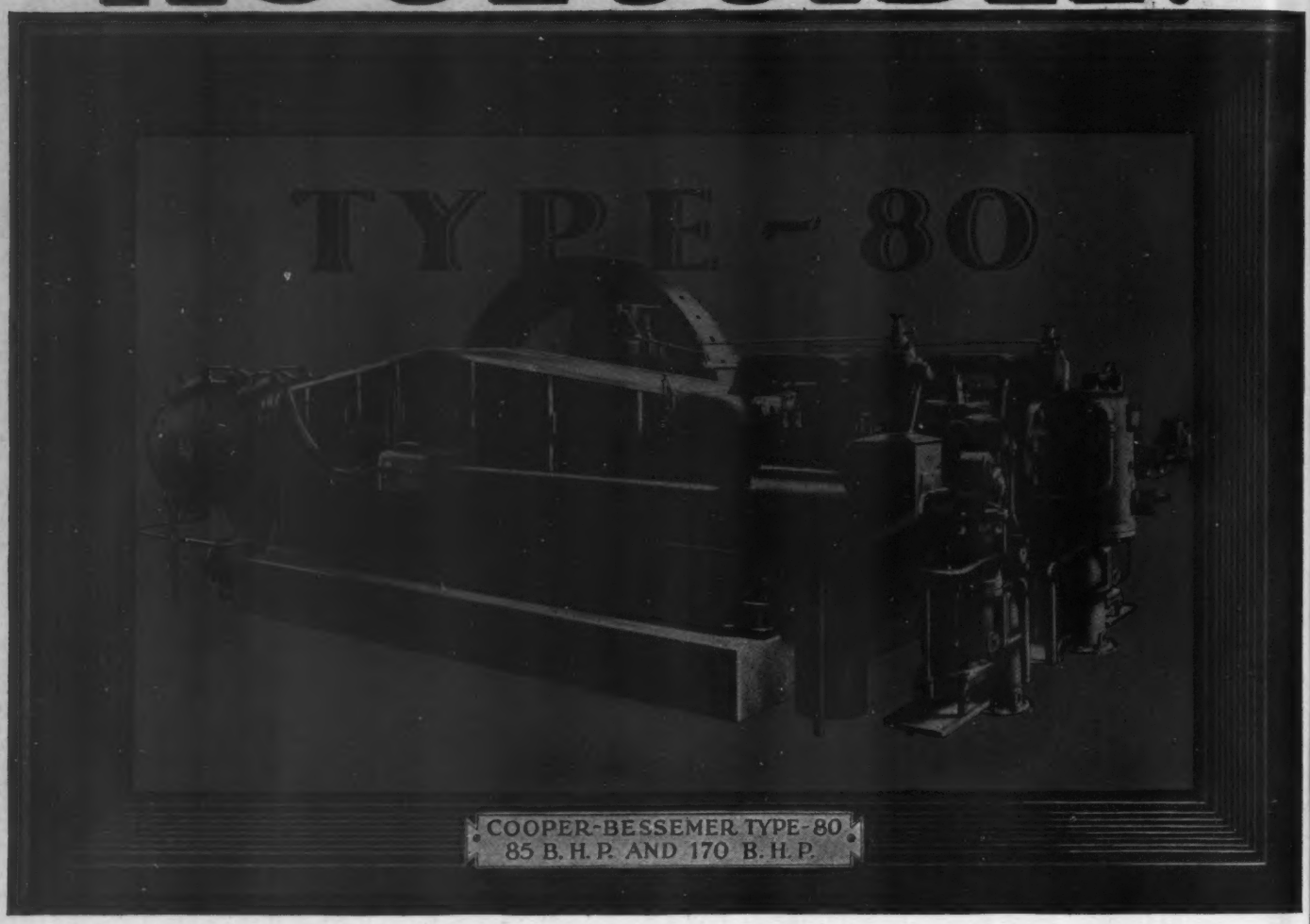

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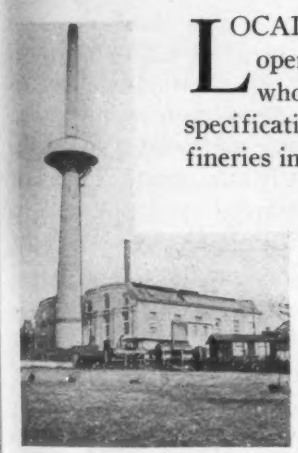
A GULF PUBLISHING COMPANY PUBLICATION

VOLUME 9, NO. 6 JUNE, 1930

French Refiners Plan Construction Campaign

By ROY E. LEIGH
*Special Foreign Representative**



LOCAL and foreign oil companies operating in the French market who have prepared plans and specifications for the construction of refineries in France, as contemplated in the petroleum law of 1928, are forced to mark time while governmental and legislative authorities continue to debate on points of policy. Participation in the ownership of the Iraq Concession, upon which are builded French hopes for the development of a national petroleum industry, has brought about a number of drastic changes in governmental policy.

First there was the law of 1928, which placed the petroleum industry of the country under the control of a commission composed of the Director of the National Office for Liquid Fuels and representatives of the ministries of War, Navy, Foreign Affairs, Finance, and Public Works and of the President of the Council, the latter to be chosen from among the members of the investigating committee of the Superior Council of National Defense. This commission is to control the industry by means of permits or licenses for the importation of crude and refined products. Permits are supposed to cover a term of 20 years in the case of crude and three years in the case of its derivatives.

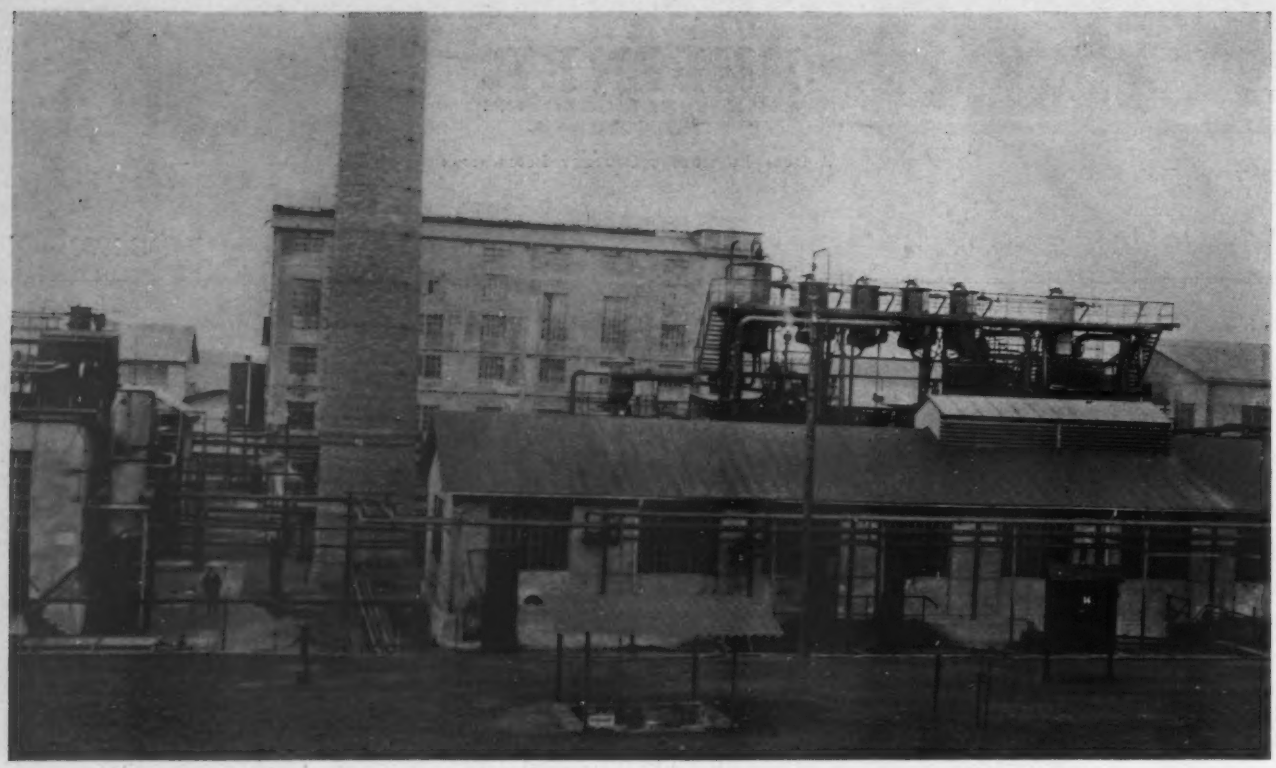
The short-term permits, which are doubtless intended to bridge the gap between the enactment of the law and the construction of domestic refining facilities which it envisages, are based on the average of each licensee's annual imports during the preceding five years. Presumably, it is the intention of the authorities to reserve the right, upon the expiration of these three-year permits, to turn over the business now based upon imported products to French companies or other specially favored concerns which meanwhile have constructed refining plants within the national boundaries.

One of the principal points at issue is the plan of the French government to acquire a 25 per cent interest in the Compagnie Francaise des Petroles, holder of 23¾ per cent of the stock of the Iraq Petroleum Company, owner of rich undeveloped petroleum reserves in Mesopotamia. Although this plan has not yet been ratified by the Chamber of Deputies, it is understood that the proposed semi-official oil company is to be specially favored in the division of the domestic market under the control of the petroleum commission. The inference is that the permits now being withheld from other companies are being held in abeyance until the semi-official status of the Compagnie Francaise des Petroles is definitely assured. While the government proposes to respect the acquired rights of companies who have heretofore supplied the French market, the tendency is to restrict their future sales to the limit of their previous averages, leaving the natural increase in consumption to be supplied by semi-official or other favored domestic enterprises.

OUTPUT PROTECTED

Another proposal, based upon a similar desire to protect the Compagnie Francaise des Petroles in the dis-

*Mr. Leigh, Associate Editor of The OIL WEEKLY, is now in Europe on the second leg of a world wide survey of the oil industry for the Gulf Publishing Company publications.



Pechelbronn Refinery, Pechelbronn-Merkwiller, Bas-Rhin, France

position of its output, is to the effect that petroleum importers shall be required to take over and market the products of the semi-official company to the extent of 25 per cent of their import licenses. It is understood that foreign companies participating in the French market have signified their willingness to accept this proposal; but that objections have been advanced by other French companies unwilling to concede such an advantage to the Compagnie Francaise des Petroles.

Other suggestions have been made to the effect that Mesopotamian oil should be prorated among all French companies, instead of being refined entirely by the Compagnie Francaise des Petroles. One faction led by Deputy Baron proposes the establishment of a national petroleum monopoly.

That the French government approaches its petroleum problem from the military angle is quite obvious, from the organization of its petroleum commission and from the nature of the various legislative proposals.

"Clemenceau Pit," Pechelbronn Oil Mine, Pechelbronn-Merkwiller, Bas-Rhin, France

France, although possessor of one of the greatest military machines of the modern world, is not happy in the realization that she cannot again go to war without the consent of another nation able and willing to supply that first essential of modern warfare—petroleum.

France has only a very limited supply of indigenous oil, including about 1500 barrels per day from 630 small wells and three oil mines at Pechelbronn, Bas-Rhin, about 1040 barrels per day from a shale plant at Autun in the Department of the Saone-et-Loire, and a small production from Gabian in the Herault.

That this limited supply would not serve to lubricate and propel French submarines, airplanes, and other engines of war is fully realized in official circles, where every effort is being made to extend and increase the country's petroleum resources. The Office National des Combustibles Liquides is directing researches in which the entire republic is being surveyed with respect to petroleum

possibilities; and, beginning in May of last year, it commenced to share with the Protectorate government and the Societe' Financiere Franco-Belge de Colonisation, etc., in the expenses of a vast exploratory undertaking in Morocco.

CONSTRUCTION PROGRAM

Indications are that, as soon as matters of governmental policy have been settled, a comprehensive campaign of refinery construction will be commenced in order to conform to the new law. Compagnie Standard Franco-Americaine, French subsidiary of the Standard Oil Company of New Jersey, has made application for licenses which would warrant the construction of a 20,000-barrel plant. It is proposed that this plant will be operated jointly by the Standard Oil Company, Atlantic Refining Company and Gulf Refining Company.

Vacuum Oil Company, Societe' Anonyme Francaise, proposes, if necessary permits are forthcoming, to construct a 5750-barrel plant, for which plans and specifications have already been drawn and construction engineers have been transferred from New York to Paris.

Anglo-Persian Oil Company, Ltd., whose existing plant at Dunkirk is not well-placed, geographically, with respect to its Persian crude supply, is said to be considering the construction of a new refinery on the Mediterranean coast near Marseilles.

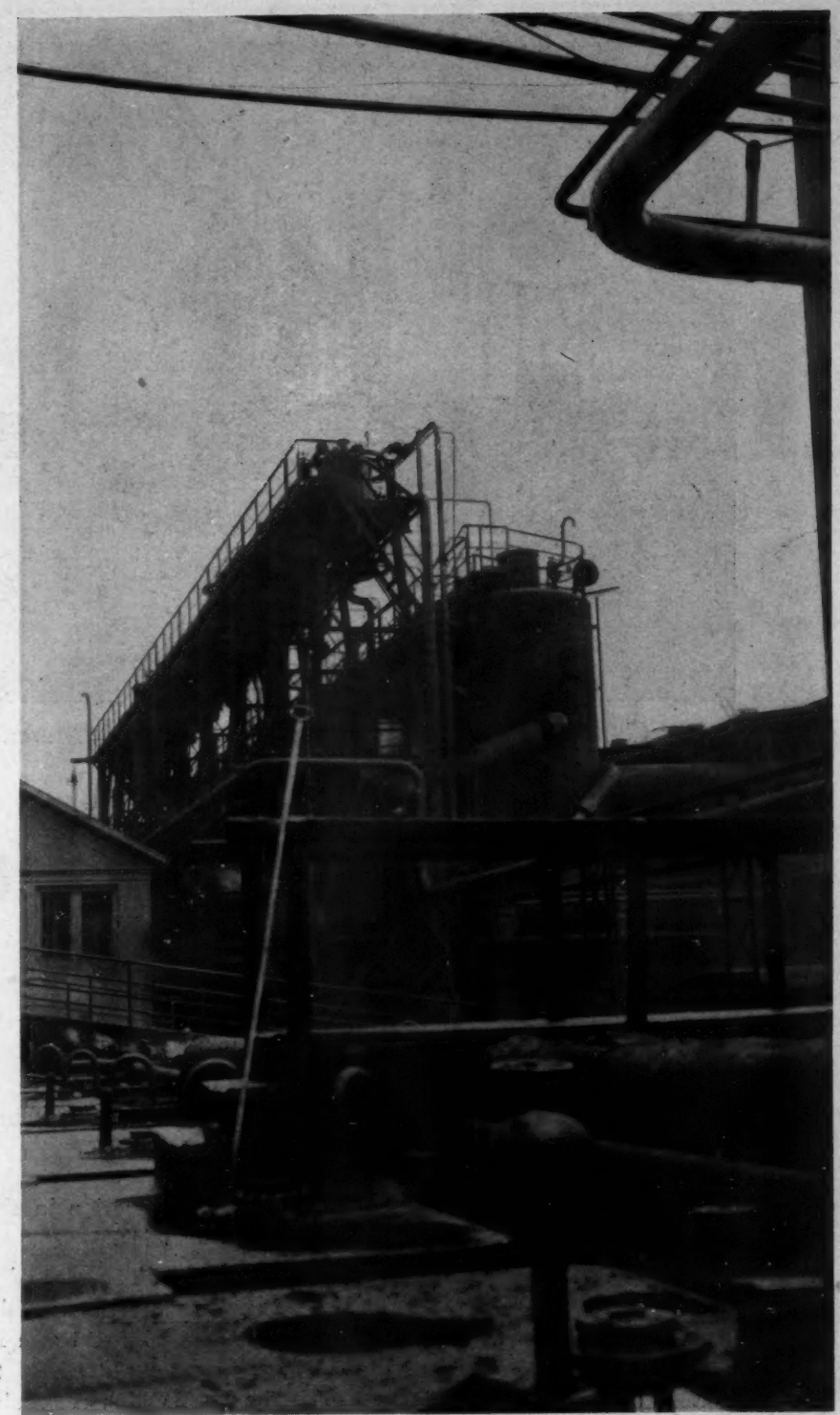
Raffinerie de Berre, a French company whose stock is owned by Saint Gobain Chemical Company, Nord et Alpes Mining Company, Urbain Corporation, and other local interests, is increasing its capital from 110,000,000 to 400,000,000 francs; and, apparently feeling none of the hesitancy which has characterized the actions of the American companies pending the settlement of legal and regulatory policies, has proceeded with the construction of a large plant near Lyons.

Jupiter, Societe' Anonyme des Petroles, Shell subsidiary and part owner of Compagnie Francaise des Petroles, is operating a 7500-barrel plant at Petit Couronne, on the Seine River below Rouen, which was completed about the middle of last year.

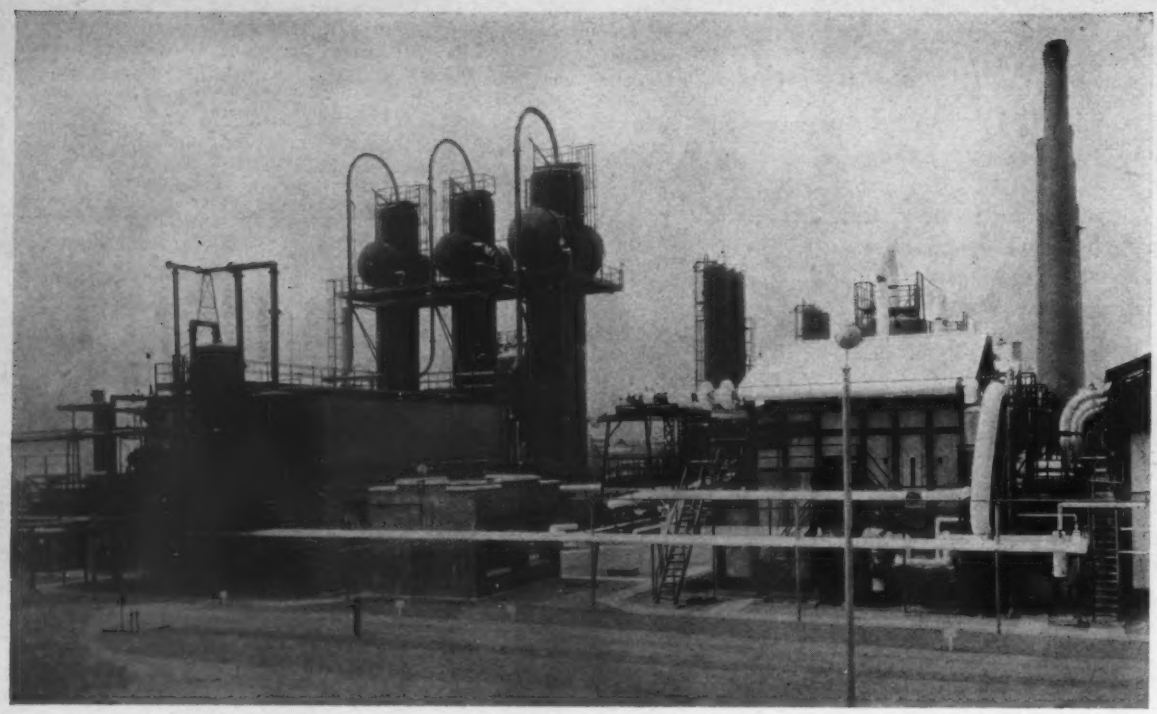
APPLICATIONS EXCEED REQUIREMENTS

Applications for licenses have exceeded the requirements of the market by about 300 per cent. French imagination has been greatly inflamed by the prospect of securing oil from Iraq; and a number of promoters or "insiders" have realized that these licenses may come to have a cash value comparable to that which now pertains to small concerns having an acquired right in the French market.

Societe' de La Mailleraye, subsidiary of the Atlantic Refining Company, of Philadelphia, has recently doubled the capacity of its plant at the La Mailleraye-sur-Seine, which is known as the largest producer of medicinal and transformer oil in the world.



Distillation Battery



Gyro Process Equipment, Pure Oil Company, Marcus Hook, Pennsylvania

Progress in Vapor Phase Cracking

By C. R. WAGNER
Chief Chemist, Pure Oil Company

THE development of the high compression gasoline engine has made it necessary for the refiner to market a fuel satisfactory for use in such engines, if he wishes to hold his trade. In order to produce such a fuel in the past he has ha dto purchase "dopes" or motor benzol with which to "fortify" his premium grade gasoline. The cost of these antiknock agents has usually amounted to almost as much as the premium he collected on his fuel, so that the process resolved itself into one of "trading dollars." This situation has naturally lead to the commercial development of phase cracking,[1] by means of which the refiner is able to produce a highly antiknock fuel from either topped crude or gas oil at a cost not out of line with the cost of gasoline made by liquid phase cracking processes. In this field the Gyro Process Company has been a pioneer. It now has more than 30 units operating or under construction in the United States and in foreign countries.

The rate of progress in this field may be graphically illustrated by reference to Figures 1, 2, 3 and 4. Figure 1 and Figure 2 show the style of installation employed in the first and second plants built, in which recirculation of flue gas was employed. Figure 3 represents the next step in the picture, where recirculation was abandoned, while in No. 4 is shown a more recent design. It will be noted in this last design that construction costs have been cut as well as operating efficiency increased. In this design the gas oil vapors are preheated quickly to a cracking temperature in small parallel tubes, and these streams of hot gas are then united into one steam where a uniform cracking temperature may be held and just enough heat added to offset the endothermic heat of reaction. By means of this style of converter yields are obtained that are strictly comparable with the small single tube unit previously described.[2] More accurate control of the reaction is possible and fur-

[1] Development of Vapor Phase Cracking by C. R. Wagner, Oil & Gas Journal, April 25, 1929. Vapor Phase Cracking by C. R. Wagner, Pet. Eng., Nov., 1929. Ref. & Nat. Gas. Mfgr., Nov., 1929.

[2] Principles of Vapor Phase Cracking, by R. C. Osterstrom and C. R. Wagner, 10th Annual Meeting, A.P.I., Dec. 4, 1929.

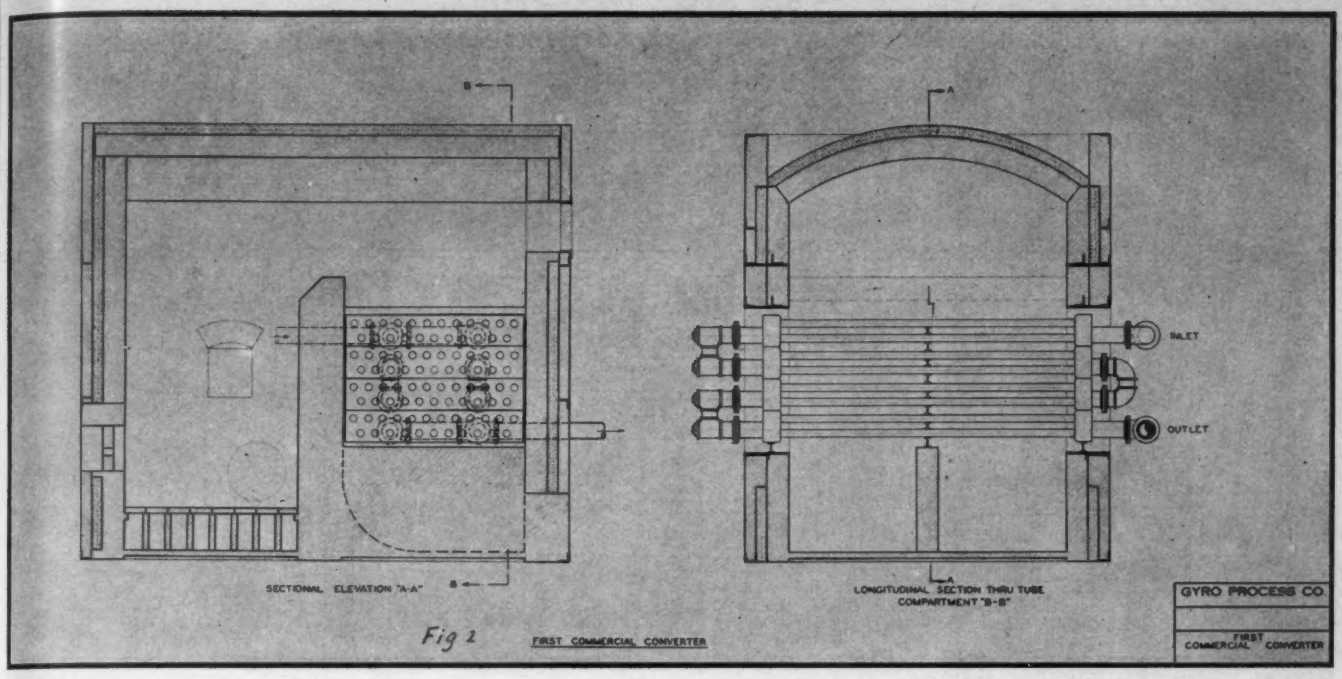


Fig 1 FIRST COMMERCIAL CONVERTER

thermore greater flexibility of operation and a considerably higher capacity are obtained.

OPERATION CONTINUOUS

An idea of the continuity of operation and of unit capacity may be obtained from the following figures taken from a plant running two 500 barrel units. These figures are for the 39 days ending March 11, 1930. These units are charging topped Mid-Continent crude and are producing a light fuel oil of 13° to 14° A.P.I. gravity.

Unit hours operated	1,857
Bbls. topped crude charged	55,397
Bbls. 430 end point distillate made	20,438
Bbls. light recycle stock made	861
Bbls. fuel oil made	27,526
Dry gas produced, M cu. ft.	33,146
Gas burned, M cu. ft.	26,254
Oil equivalent of gas burned, bbls.	6,313
*Percent fuel on charge	11.4

*It should be pointed out that this fuel includes that necessary to do the rerunning and to produce steam enough to run all of the pumps in connection with the process.

An understanding of the operation of the Gyro Process may be had by reference to the flow sheet shown in Figure 5 and the following explanation.

PROCESS DETAILS

Owing to the method used in delivering vapors to the converter it is possible to handle any grade of oil as charging stock. Fractions boiling within the range of the motor fuel desired are eliminated at once and by control of the oil line temperature and

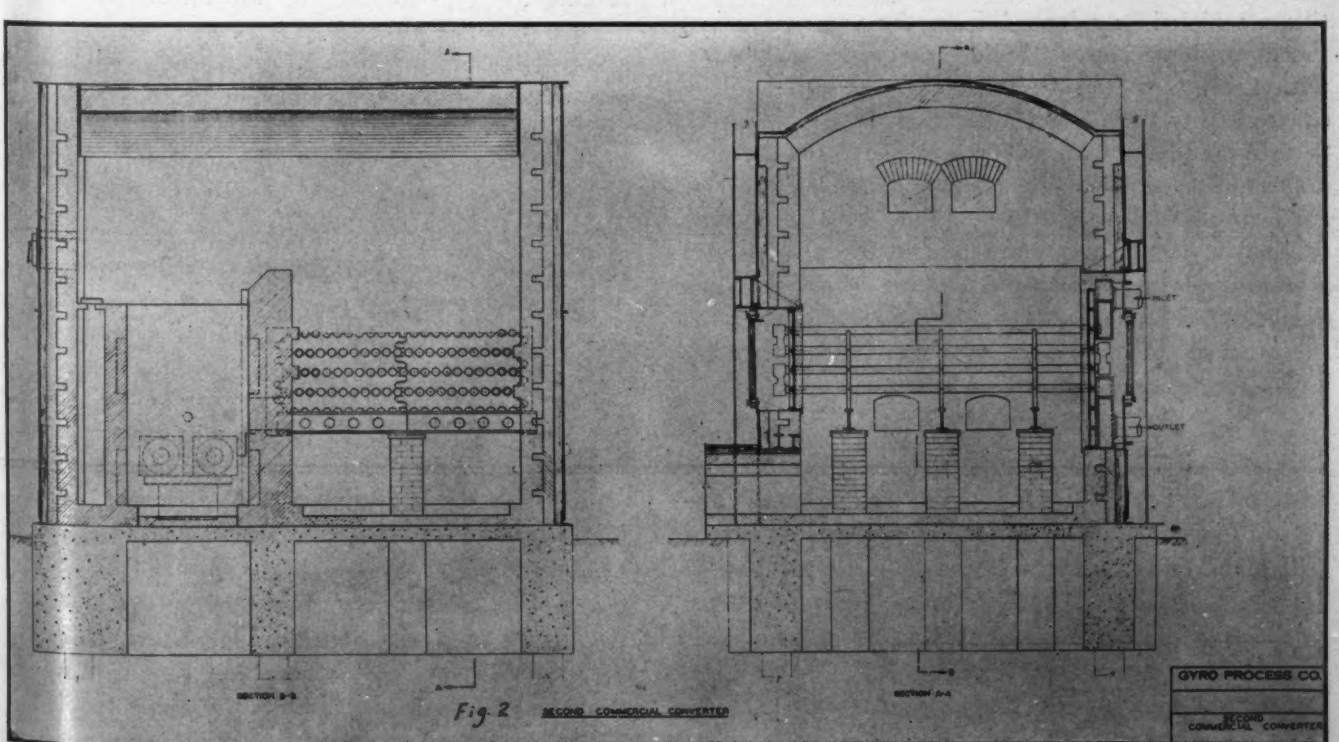


Fig. 2 SECOND COMMERCIAL CONVERTER

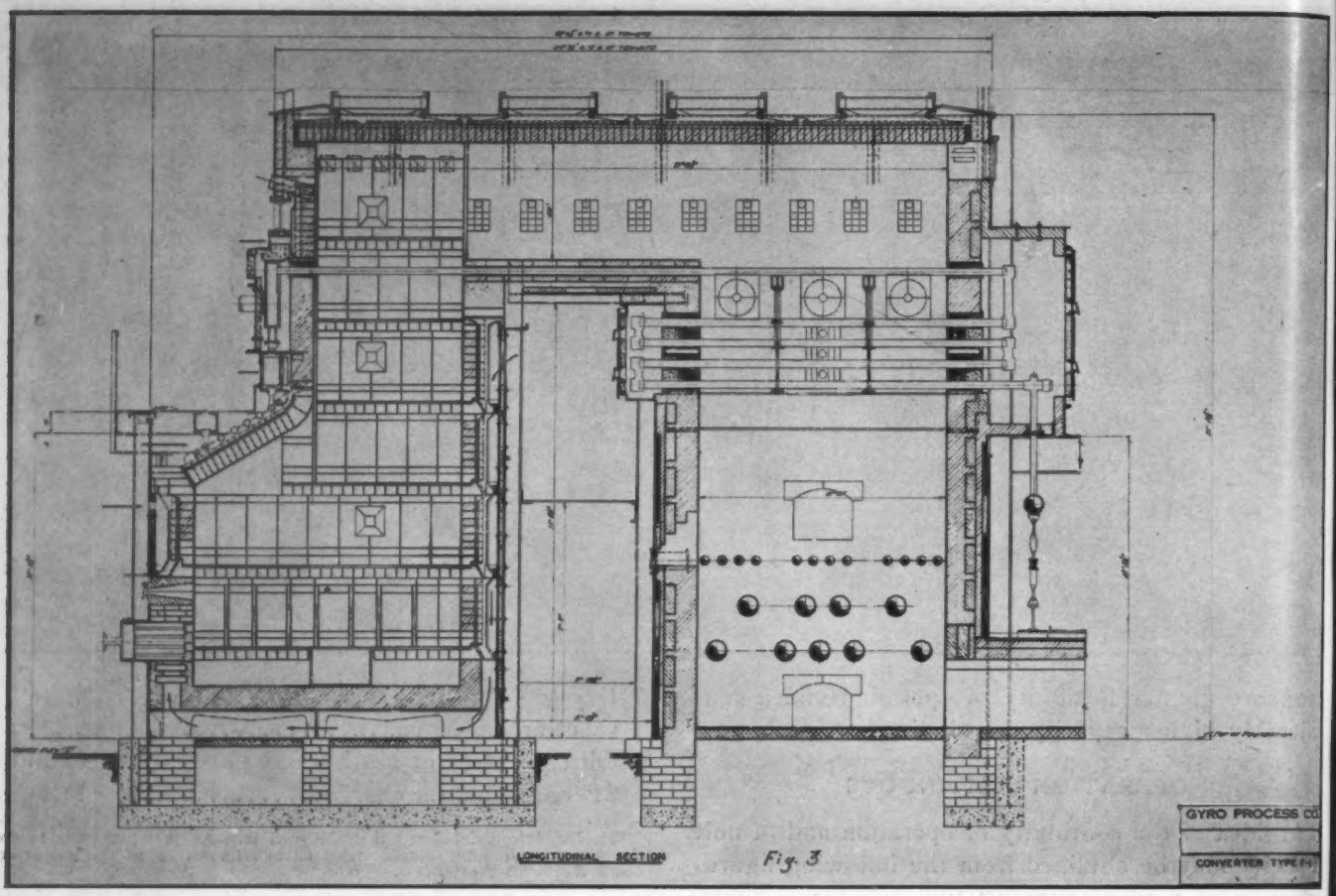


Fig. 3

rate of steam flow into the evaporator as much as or as little of the charging stock as desired may be eliminated as fuel oil. Charging stock from the tank (A) is delivered by means of the pump (B) to the arrester (C) spray nozzles where the vapors leaving the converter (I) are reduced in temperature from about 1100°F. to 600°F. The liquid and vapors from the arrester pass to the fractionating tower (J). This fractionating tower is so designed that the distillate which is condensed from the vapors leaving the top of it will have a boiling range commensurate with the motor fuel desired. This boiling range is controlled by means of the refluxer (O) which may be arranged, as shown on the flow sheet, for the production of low pressure steam. The quantity of steam produced in this manner is more than enough to operate all of the pumps used in the process and to supply all of the required process steam. The gas from the gas separator (L) is led to a compressor for the recovery of its liquefiable motor fuel content by any suitable method.

The hot oil reservoir (D) acts as a collector for all of the oil which enters the system which has not yet been converted into motor fuel or fixed gas. The hot oil pump (E) is controlled as to speed so that it will maintain a constant liquid level in the hot oil reservoir, (D). The quantity of this hot oil delivered to the economizer (F) is regulated by an automatic rate of flow controller. This rate of flow is so maintained that the converter is constantly supplied with the correct quantity of vapor. The balance of this hot oil is returned to the charging stock tank (A) through either heat exchangers or coolers.

The portion of the hot oil which passes through the economizer leaves the economizer (F) at a temperature of about 700 degrees Fahrenheit and enters the evaporator (G). Here the fuel oil drops out as residum and is removed from the system through the cooling coil (Q) to the fuel oil tank (R). Superheated steam is introduced into the system through perforated coils in the bottom of this evaporator in quantity not to exceed three per cent by weight of the vapors produced. The vapors and steam leaving the top of the evaporator pass through separator (H) which removes particles of entrained liquid.

From the separator the vapors pass through a series of preheater or drying tubes in the bottom part of the converter (I) to the inlet of the converter. In these drying tubes the vapors are given about 30° to 50°F. superheat which suffices to remove the white fog that always accompanies any stream of saturated gas oil vapor. These fog particles are in reality tiny drops of liquid oil and unless removed cause some difficulty in the operation of the converter. In passing through the converter the temperature of the vapors is increased to approximately 1100°F. and the conversion to lighter hydrocarbons occurs at this point. In this converter the vapors are distributed by means of the inlet header and passed through a number of tubes in parallel, the tubes containing

catalytic cores. From the outlet of the converter (I) the vapors pass into the arrester (C) which was described above.

It is seen from this description that every effort is made to avoid cracking in the economizer and evaporator, since low boiling fractions in passing through the converter are decomposed almost as readily as gas oil fractions. The larger part of the end products from such a decomposition is found in the fixed gas. For the same reason the raising of the vapors to the cracking temperature is done as quickly as possible. It is known also that any gasoline made at such low temperatures which might pass through the reaction zone unchanged would have inferior antiknock properties.

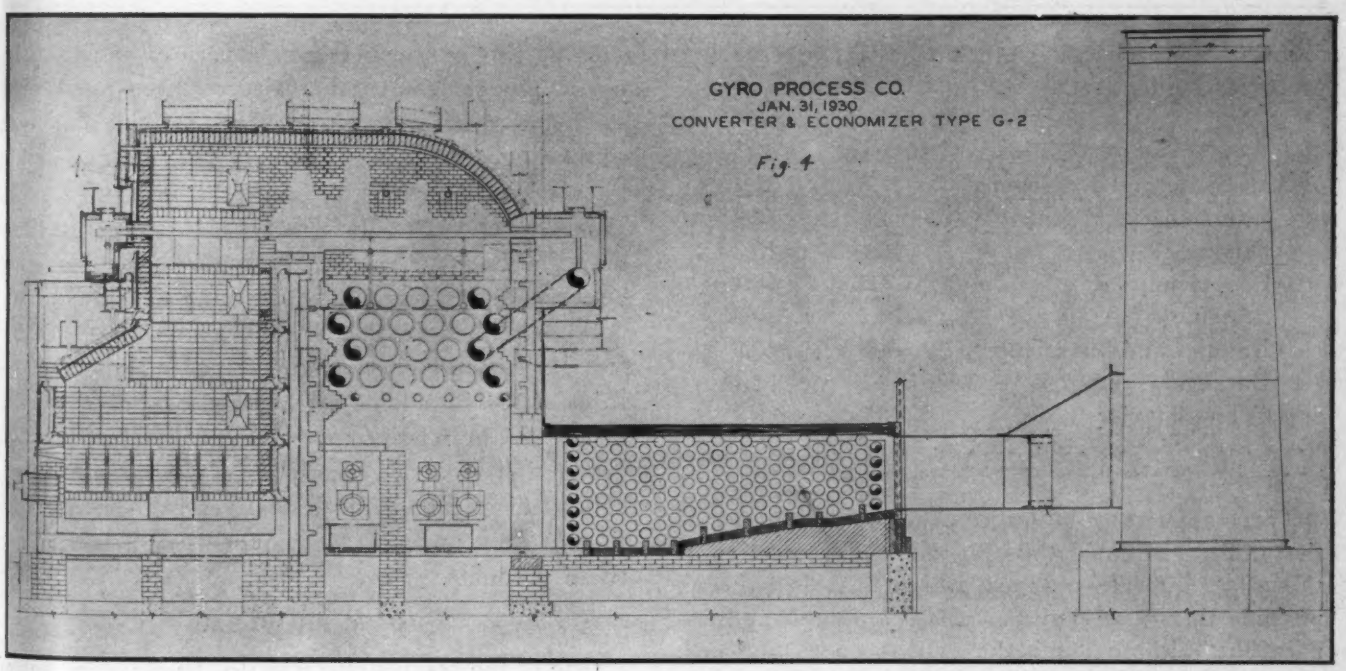
GASOLINE FROM FIXED GAS

One of the most interesting developments has been that involving the conversion of a goodly part of the fixed gas into motor fuel. By this process it has been found possible to convert half of the gas produced into a high grade motor fuel rich in cyclic hydrocarbons and having a lower average distillation range than U. S. motor gasoline. This product has a higher antiknock value than the distillate produced by the original vapor phase cracking, and after refining yields a stable fuel. In places where the value of the fixed gas is low because of a lack of outlets in the gas industry or in organic chemical synthesis this development offers the refiner an unusual opportunity for enhancing yields and profits. When combined with recent adaptations enabling the refiner to charge to the process pipe still bottoms some very interesting facts appear. For instance, by such methods it is possible to recover 40 per cent or more of 420°F. end point finished motor fuel from a 15.0° A.P.I. pipe still bottom from Mid-Continent crude. When it is considered that this material is generally regarded as a low grade fuel oil, the possibilities of the process are apparent.

The following table illustrates the yields obtainable from Mid-Continent crude charging stocks by a combination such as that described above.

	15° A.P.I. Pipe Still Bottoms	27° A.P.I. Topped Crude	30-34° A.P.I. Gas Oil
Finished Motor Fuel	40.9	57.0	75.1
Fuel Oil	45.3	30.9	11.4
Gas (1350 B.t.u.)	10.9	11.9	12.5
Loss	2.9	0.2	1.0

In the refining of the distillate produced equally great strides have been made. In the beginning yields of 80 to 85 per cent finished motor fuel from end point distillate were to be expected. Constant work along this line has developed a series of treating methods, just as was done in the case of liquid phase cracked distillate. As a result of this work it is possible today to treat end point vapor phase distillate so as to produce 95 per cent of finished water white product. In the case of high sulphur distillates losses will be somewhat greater, if it is necessary to reduce the sulphur content to less than 0.10 per cent. It should be remembered, however, that the sulphur content of vapor phase cracked distillate is usually very much lower than would be the case if the same oil were cracked in the liquid phase.



TYPES OF GASES

The gases produced by vapor phase cracking are quite different than other refinery gases. Below are given analyses of two samples of gas from the same

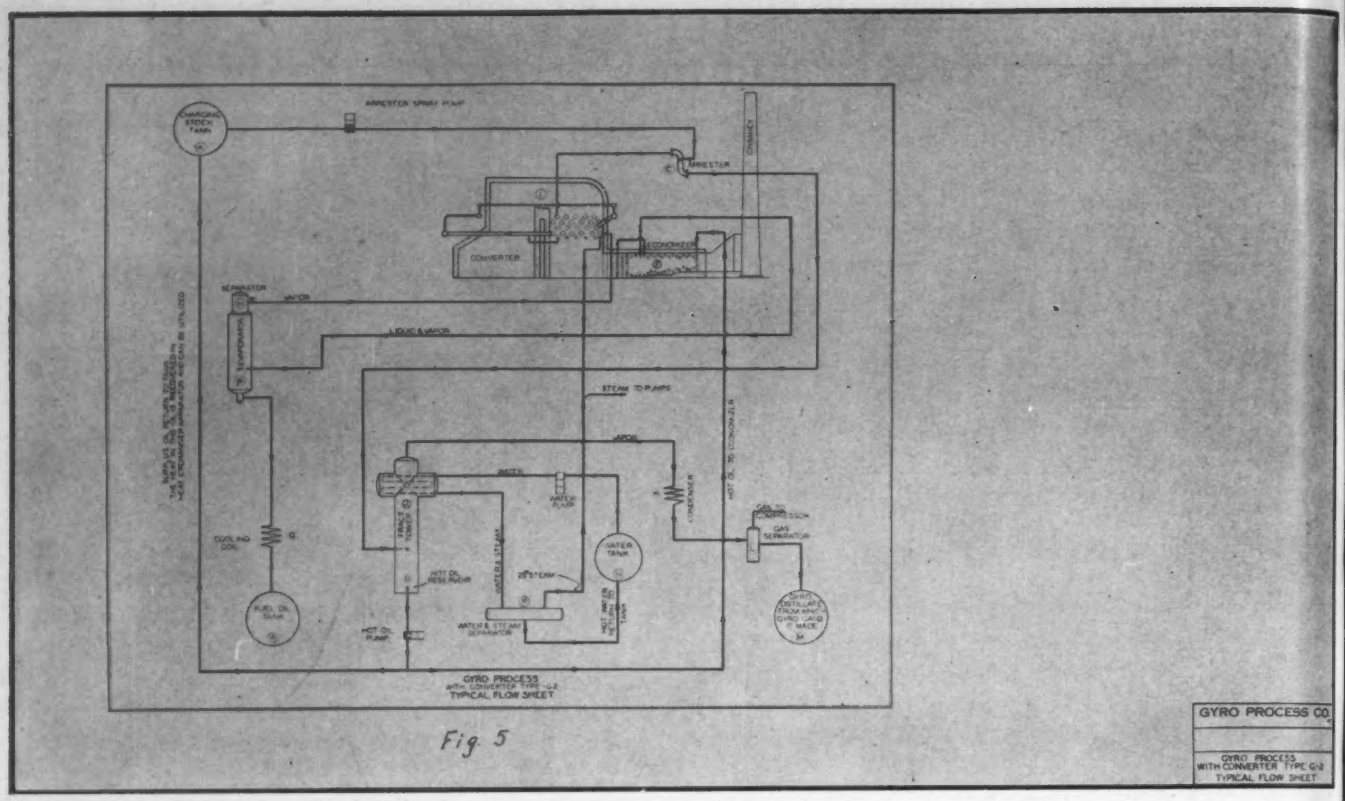


Fig. 5

refinery. The charging stock to the two cracking processes is identical.

	Cross Process	Gyro Process
Methane and hydrogen	46.3	35.4
Ethylene	1.23	22.9
Ethane	16.6	13.3
Propylene	5.3	18.1
Propane	16.2	0.0
Butenes and butadiene	4.3	5.5
Butanes*	6.1	1.4
C_5 and heavier	3.7	3.4

*There is as yet some question as to the accuracy of this determination. It is possible that these two belong with the butenes.

There appears to be no propane present in any of the gasses examined thus far, although some, as in this case, indicate butanes present. It is believed possible that these may be cycle-compounds and not paraffine, although this has not been established. Further work is now in progress, and in the near future it is hoped that announcement may be made of the effect upon gas composition of varying charging stocks and cracking conditions. Contrary to previous reports on the subject, it is now known that some effect upon gas composition is caused by changing the charging stock to the process. It is not yet known, however, by what mechanism gas molecules are produced nor why the composition of the gas varies.

It must be readily apparent that a raw material such as this gas would have a variety of uses. Its use in gas enrichment has already been mentioned, as have also the installation of commercial plants for converting ethylene, propylene and butene-1 into their corresponding alcohols, acetates and glycols. Isobutene and 1, 3-butadiene are also present in these gases, although the quantitative relations existing between these compounds are not yet known. We do know, however, that already nearly 200,000 cubic feet per day of isobutene and somewhat lesser quantities of 1, 3-butadiene are being produced in such a form as to be readily recoverable at low costs. The production of large quantities of tertiary butyl alcohol and of butadiene derivatives is therefore contingent only upon the development of a market for these products.

GUM PROBLEM

One of the serious obstacles to the development of vapor phase cracking has been the gumming tendency of the motor fuel produced. It was necessary to overcome this difficulty, therefore, before such a fuel could be safely marketed. This has involved a tremendous amount of work on the nature of gum formation and the development of satisfactory methods for determining gum in motor fuels. Preliminary reports[4],[5] have been made on these investigations and present indications are that a method for determining gum will be in shape to offer to the industry by the end of the year. Chemical treatment of these highly cracked motor fuels has been developed to the point where it is now possible to insure their

(*Continued on page* 162)

[4]Factors Affecting the Determination of Gum in Gasoline, by C. R. Wagner and Julius Hyman. Tenth Annual Meeting, A.P.I., December 5, 1929.

[5]Autoxidation of the Amylenes, by Julius Hyman and C. R. Wagner, Petroleum Division, American Chemical Society Meeting, Atlanta, Ga., April 8, 1930.

Refiners May Market Fixed Gas In Tank Cars

By PAUL TRUESDELL

NEW methods of utilizing to better advantage gases generated in the distillation and cracking of petroleum were discussed at the meeting of the American Gas Association in Cleveland, May 21-23.

These methods open the way for the refiner to new profits from by-products which hitherto have been largely wasted or applied to uneconomic purposes—that is, refinery gases.

Realization, to the fullest extent, of the possibilities and benefits lying just ahead will call for a new measure of cooperation between the oil refining and the gas manufacturing industries, it was pointed out.

Two chief methods were set forth for the better utilization of refinery gases. One was the so-called "reforming" of refinery gases, which is thus described by Dr. Gustav Egloff of Universal Oil Products Company.

"The 'reforming' of hydrocarbon gas is accomplished by cracking, so as to produce two or more volumes of gas having a lower B.t.u. content per cubic foot than the original gases converted. In the 'reforming' process the cracking reaction produces a large volume of hydrogen having a low B.t.u. content per cubic foot. Inasmuch as the refinery gas contains from 1200 to 2000 B.t.u.'s per cubic foot, and the usual legal requirement of towns and cities is 530 B.t.u. per cubic foot, the effect of 'reforming' is to dilute the gas to the regular B.t.u. standard, at the same time greatly multiplying its volume."

The other method proposed was the distribution in liquid form of propane and butane for heating and refrigerating purposes. The time is probably not far distant, when propane and butane from the refinery and natural gasoline plants will be generally distributed for heating and refrigerating purposes.

The distribution will be in liquid rather than gaseous form, and the materials will be transported in tank cars and tank trucks as gasoline is now. The gas companies with their wide public contact and service facilities, it was predicted, will handle the delivery of the gases to the consumer.

Dr. Egloff, under the title, "The Cracking of Heavy Oils and Tars," emphasized the importance of the cracking process, not only as a provider of gasoline, but also as a factor in the gas supply.

He pointed out that the total quantiy of gas produced in refineries as by-products of distillation and cracking operations exceeds the volume of manufactured gas made in the United States. Not only this, but the B.t.u. content of the refinery gas is more than double that of the manufactured gas.

Perhaps the most interesting proposition put forward at the meeting was that of H. Janney Nichols, Jr. of the Standard Oil Company of New Jersey, under the title, "Relationships between the Petroleum and Gas Industries."

Mr. Nichols questioned whether propane and butane have reached their highest usefulness when used for enrichment of water gases for "reforming" and for cooking in suburban and country homes. He proposes what he believes more advantageous use of these gases as follows:

INDUSTRIAL USES

"It would seem that a much larger outlet for these liquid gases is in industrial plants where fuel is required in gaseous form. To such plants propane and butanes may be delivered by tank cars as a liquid. One cubic foot of liquid propane when vaporized at standard conditions becomes 277 cubic feet of propane gas. Why vaporize this one cubic foot of liquid into your gas holder as 277 cubic feet of gas for enriching purposes, or as 900 to 1300 feet of a reformed gas.

"You know quite definitely what gas of 530 B.t.u. costs in the holder. If this cost be 30 cents per 1000 cubic feet, then one gallon of propane, in the holder, is worth only 5.3 cents on a B.t.u. basis. Gas is sold by volume but since the B.t.u. value is very definitely set, the gas industry is actually selling heat units. From this it follows that a gallon of propane used for enriching purposes is worth to the gas industry only what it costs to get 93,000 B.t.u. in your holder.

"To reform this gallon of propane is only confusing the issue by spreading out the same number of

(*Continued on page 162*)

EDITORIALS

OUT of the investigation of possibilities of standardization of refinery equipment recently authorized by the Refining Division of The American Petroleum Institute will come much that is of value to the industry.

A committee on standardization appointed last month, by the very nature of its personnel, augurs well for the preliminary efforts. The findings of this investigatory committee when reported at Chicago in November will prove of interest in that the real need for standardization of refinery equipment, especially the auxiliary equipment so essential to plant operation, will be emphatically brought to attention. With numerous sub-committees appointed with membership from all leading refiners and leading manufacturers of refinery and natural gasoline plant equipment, and with the experience of the production equipment standardization committee to guide them, the work will progress rapidly.

With this work started, which can become successful only through the collective efforts of the refiners themselves, an opportunity is presented to accomplish results comparable to the American Petroleum Institute's standardization work in the producing branch of the industry. The speedy conclusion of the standardization effort is possible through cooperative efforts of refiners. The economies of labor, time and materials possible of attainment through its successful and early conclusion are well worth the effort required.

There is no department of the refinery but that the need of standard methods, dimensions, quality of materials and the like, is felt. With the present rapid adoption of high capacity vacuum distillation units, two-stage atmospheric vacuum units, higher capacity liquid and vapor phase cracking facilities, all that enter into the assembly of such units insofar as materials, piping, valves, fittings, control devices, refractories, brick work, insulation, structural steelwork and many other items, can be studied from the viewpoint of standardization.

Essential materials from a quality standpoint, auxiliary equipment, and the like, required in the present extensive utilization of such phases of manufacture as extreme low temperature refrigeration, liquid sulphur dioxide process of treating, vapor phase refinement, solvent extraction of waxes, oxidation processes, hydrogenation developments, debutanization or degasification systems, vapor recovery units, can well come under the scrutiny of the committees investigating standardization.

Storage facilities, transportation equipment, shops, change-houses, laboratories and their apparatus, plant transfer or distribution facilities, chemical treating systems and chemicals reclamation processes, if included tend to make the task bigger, of more importance and of greater value.

One group of refiners was early to realize the need for standardization of testing methods and their application to finished products. From their early endeavor has grown the present petroleum products specifications and methods of testing. Such work was essential. Without its success refining would be a poor business indeed.

UNITED STATES BUREAU OF MINES, through its Petroleum and Natural Gas Division, conducts investigations dealing with petroleum, natural gas, oil shale, their products, and safety in the petroleum industry. Reports of such investigations are made in the form of "Bulletins," "Technical Papers," "Reports of Investigations," and "Information Circulars." Subjects of great length and deserving of considerable amounts of time are presented in the form of bulletins or technical papers. These reports, due to the amount of time required in their preparation, usually are not available to the public until after the object of study has become stabilized and the information is, therefore, somewhat retrospective. For these reasons the shorter subjects are presented in "Reports of Investigations" and "Information Circulars" and in many cases various stages of the lengthier subjects are so reported in order that data may be made available at a time when it is most needed.

The bureau is preparing a revised mailing list for distribution, without cost, of mimeographed reports dealing with petroleum, natural gas, oil shale, their products, and safety in the petroleum industry. Many of those who receive the bulletins and technical papers do not know of this mimeographed service and are not on the present mailing list for such reports. In order that members of the industry who are interested in receiving this service, circular letters are being mailed to those whose names and addresses can be obtained. In the belief that many interested persons will not be reached it is suggested that the coupon below be filled in and mailed directly to the United States Bureau of Mines, Washington, D. C.

Name .....
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Check publications desired:

—1. Production, transportation, and storage of petroleum and natural gas.
—2. Chemistry and refining of petroleum.
—3. Safety in the petroleum industry.
—4. All mimeographed publications dealing with petroleum, natural gas, oil shales and their products.
—5. Government printing office periodical notice (postcard lists) of Bureau of Mines publications.

Chemical Treatment of Petroleum Distillates

III. Cracked Distillates

By L. J. CATLIN
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IT is no longer necessary to explain to the average man about the refinery, or even to the layman outside, what is meant by the term cracking in the petroleum industry, at least so far as results are concerned. To the consumer of gasoline it means "two blades growing where one grew before"; that is, 15-cent gasoline where formerly he paid 30 cents. It means cars for everybody where formerly they were only for a few wealthy people, because it has permitted unrestrained mass-production on the part of the car manufacturer with no misgivings as to the ability of the petroleum industry to meet their lowering of original cost of cars with a corresponding lowering of the cost of operation. To the average man about the refinery it means seemingly unending replacement of old equipment with new, with ever-increasing size of units, and complexity of design. It means heavy oil fed into a still to yield lighter distillate and still heavier residue. It means more frequent cleaning of stills and fuel tanks, more frequent inspection of equipment and larger factors of safety on account of higher pressures. To the treating plant operator it means more distillates to treat and increasing difficulty in bringing them up to former standards. In the chemical laboratory it means higher educational requirements along ever-broadening technical and engineering lines, as well as ever-increasing understanding and appreciation of the details of plant routine. To every man on the refinery force it means increasing responsibility for personal alertness to changing demands, and collective, cooperative effort.

The attitude of the public toward the art of cracking has undergone as great changes in the last decade as has its attitude toward card playing, and that means all the way from a belief by many that it was an unmitigated evil to acceptance and striving to excell in the art. Advertising campaigns and sales talk have centered on various phases of the question until everybody knows more or less about it. Many who formerly shied at the idea of using cracked gasoline are now paying a premium for it. Its place both in the industry and in public demand is well established but a multiplicity of new terms leaves the average person more or less confused as to which are merely trade names and which are scientific terms. Chemists are often accused of talking in unknown tongues, but for the encouragement of treating plant operators who haven't studied chemistry we may say that a treatise on cracked gasoline using such chemical terms as are most frequently used in the scientific literature on the subject involves fewer strange words and complicated concepts than many of the sales' bulletins which pose as being practical. We strongly advise becoming familiar with correct chemical terms and shall use them freely in this discussion without apology, at the same time attempting to show their significance in terms of practical operations.

Without attempting a general elementary discussion, let us say in passing, that hydrocarbons are compounds containing only the elements carbon and hydrogen, and that the chemist making a study of them soon finds that there are certain characteristic groups the same as there are different breeds of horses, cows and dogs. The groups with which we will be mainly concerned are called respectively, paraffins, olefines, or unsaturated hydrocarbons, naphthenes, and aromatics.

PARAFFIN AND ASPHALT BASE

In the beginning let us look at two terms which have been used almost from the beginning of the petroleum industry, namely, paraffin base and asphalt base as applied to crude oil. Everyone recognizes that these represent two different types of crude oil, but the question often occurs to the average man as to just how this classification applies to a particular sample or how it is determined.

These are not scientific terms in the strict sense because they cannot be definitely defined as applied in this case, and the line of demarcation between them is only relative. A good discussion of this subject is to be found in a Report of Investigation, Serial No. 2806, of the Bureau of Mines, by N. A. C. Smith, which we quote in part:

"The writer has talked with many oil producers and refiners and has come to the conclusion that the word 'base' is used much as it is in pharmaceutical work. For example, the 'base' or 'basis' of an ointment or salve is the fatty material (lard, petrolatum, lanolin, etc.) used as a vehicle or carrier for the active medicinal principles. Apparently many of the pioneers in the petroleum industry conceived of crude oil as being similar in nature to these medicinal products, in that it con-

sisted of a semi-solid non-volatile 'base' and a volatile portion which could be distilled off to make gasoline, kerosene, etc. Many crude oils when chilled slowly will deposit a waxy material ('paraffin') and this fact may have been one of the reasons why these oils were spoken of as having a 'paraffin base.' Historically, it happened that the oils first discovered in this country were almost all of this kind and it was only when the oil industry developed in California and along the Gulf Coast that oils were found which contained no wax but which apparently did contain asphaltic material. These oils were accordingly known as 'asphalt base' oils. The use of this term, however, seems unfortunate as the better grade crudes of this type contain little if any asphalt. This fact has apparently been recognized in the petroleum industry and the more descriptive term 'naphthene base' is frequently used in the place of the term 'asphalt base.' Oils that cannot be assigned to either the 'paraffin' or 'naphthene' groups are usually classed as 'intermediate-base' crudes. These 'intermediate-base' oils in general resemble 'paraffin-base' crudes much more than they do 'naphthene-base' crudes. It is however the belief of the writer that a fourth type of crude exists that resembles an oil of the naphthene-base crude except that it contains a small amount of waxy material. To distinguish this type from an intermediate-base oil it has been given the name 'hybrid-base crude.'

Distillation curves have been prepared for typical samples of each class here described showing the relation of boiling point to gravity in degrees A. P. I. for atmospheric distillation up to 275° C. and then for vacuum distillation up to 300°C. More specific data on this part of the subject will be given in connection with tests for the laboratory, but a brief summary of the method may be given by quoting two more paragraphs from the above mentioned report:

"I.—Note the A. P. I. gravity of the 'key fraction No. 1,' that is, the fraction distilling between 250 and 275°C. (482-527°F.) at atmospheric pressure. If this gravity is 40° A. P. I. or lighter the oil can be considered definitely to have a paraffin base. If this gravity is 33° A. P. I. or heavier the oil has either a naphthene or hybrid base. If it is between 33 and 40 the oil has an intermediate base. ... II.—note the 'cloud point' of 'key fraction No. 2,' that is, the fraction distilling between 275 and 300°C. (527-572°F.) at 40 mm absolute pressure. If this cloud point is reported as being below 5°F., it indicates that wax is absent and that the oil has a naphthene base. If, however, the cloud point is above 5°F. it indicates the presence of wax and that the oil may have a paraffin, an intermediate, or hybrid base."

From the foregoing we may see that the question of base of crude oil is at present decided by more or less empirical standards and will probably remain so till more research is carried on to show more definitely what compounds are found in different crudes and methods devised for determining the different groups as they occur in the crude oil. These problems to be worked out by chemists will have a bearing on treating plant control. However, it would be rather hazardous at this time to predict what the attitude of the industry and the public will be toward the different types. It might perhaps be said that the discussion will be more concentrated on the lubricating fractions than on the light fractions here considered.

In contradistinction to these rather indefinite, and arbitrary classifications of crude oils, we have in the case of cracked distillates the four chemical groups named above whose general formulas are known and whose general characteristics have been studied. Some of the individual compounds in these respective groups have been identified in distillates and methods for separating the groups from one another are being studied and used in control work. This is of course the laboratory angle, but changing practises at the treating plant invariably follow any advance in definite knowledge of, and methods for readily determining the different constituents of distillates being treated. A general knowledge of these groups will prove quite practical to the treating plant operator and aid in understanding the work of the laboratory.

THE PARAFFIN GROUP

Webster's New International Dictionary says the word paraffin is "derived from the latin parum, too little; and affinis, akin. So named in allusion to its chemical inactivity." Incidentally, it also gives the other spelling, with a note saying "In present chemical usage this word is spelled paraffin, but in commerce commonly paraffine." The layman thinks of paraffin as a wax, and as naturally would be supposed, paraffin wax does belong to the chemical group of pariffin hydrocarbons, but constitutes only a small portion of the group, the members of which have the common chemical property of "Inactivity" toward many of the common reagents, as well as other common characteristics revealed by chemical study. An outstanding chemical characteristic of the group is the ratio of carbon to hydrogen in the molecules of its members, which is expressed in the general formula C_nH_{2n+2}; where C and H refer respectively to carbon and hydrogen, and N stands for any number designating how many carbon atoms are in the molecule. That is, if N is one, or in other words there is just one carbon atom, hydrogen will have as many atoms as $2n+2$ or four atoms, and the molecule will have the formula CH_4, which is the formula for methane. The next in the series will be where N equals two and the formula will be C_2H_6, which is ethane, etc.

Chemical theory shows why compounds having this general formula are chemically inactive but that is beyond the scope of this discussion, except to say that this particular ratio or relation of carbon to hydrogen allows a structure of the molecule in which there is least strain on the bonds uniting the carbon and hydrogen atoms together. These are also called "saturated" hydrocarbons because all the bonds available on the respective atoms are in use and there is nothing to which an out-

side chemical substance may attach itself without first displacing an atom already present. The practical significance of these chemical properties is at once apparent. It is not to be inferred, of course that these hydrocarbons will not take part in any reactions, but that with ordinary chemical reagents at ordinary concentrations no action takes place; and further, that before anything can attach itself to the molecule it must first break off or displace something already in the molecule.

To summarize the properties of the paraffin hydrocarbons in practical terms as they apply to the lighter distillates, we may say that they are light in gravity as related to boiling points; they give little or no reaction with ordinary treating agents such as sulphuric acid and caustic; they possess very little color; are very stable with respect to color and gum-forming properties; and are the worst offenders with respect to detonation or knocking in engines.

OLEFINES OR UNSATURATED HYDROCARBONS (C_nH_{2n})

In this group, the term "unsaturated" refers to the chemical structure of the molecule, and the resulting chemical properties. The relation of carbon to hydrogen as expressed in the general formula given above does not permit all the bonds of the carbon atoms to be used in the simple unstrained manner characteristic of the paraffins, but requires that two of the bonds be either unattached, or as is more generally assumed, attached to each other which might be considered as an unsaturated condition. This brings about a structure which in general is explained by showing two carbon atoms in the molecule which are attached to each other by a double bond. But this double bond has the opposite effect from that ordinarily thought of, in that instead of strengthening the union it weakens it. We may think of the bonds as repelling each other like similar charges of electricity or other cases where like repels like. The resulting chemical property is one in which another element, or a similar bond from another molecule may attach itself without displacing any element in the molecule, thus carrying out the idea of unsaturation.

Mono-olefines are those in which the double bond between carbon atoms occurs but once in a molecule. If two such double bonds occur in the molecule it is classed as a di-olefine. When both sets of double bonds occur on a single carbon atom within the molecule it is styled as a conjugated di-olefine. These three types naturally result in differing chemical properties characterized by increasing degrees of unsaturation. Again the practical significance of the chemical properties is at once apparent; and speaking in practical terms, as in the case of the paraffins, we may say that distillates containing olefines are of slightly heavier gravity for corresponding boiling ranges; react readily with a number of treating reagents; have a little more odor and color; are less stable with respect to color and gum; and are good anti-knock fuels if used before any of these unstable conditions have expressed themselves. However, the changes which may take place in storage tend to nullify any superior anti-knock qualities at the same time that color and gum are being developed.

NAPHTHENES (C_nH_{2n})

The general formula in this case is the same as for the olefines, but there is a distinct difference in the structure of the molecule. The naphthenes are of a cyclic, or ring structure while the olefines are of a straight-chain structure. They have the maximum percentage of hydrogen possible under the cyclic or ring structure, and act chemically under ordinary conditions somewhat similar to the paraffins, but have better anti-knock properties.

AROMATICS, OR BENZINE GROUP (C_nH_{2n-6})

These hydrocarbons are typical of the coal tar distillates. The first three members of the series are benzene (C6H6), toluene (C7H8), and xylene (C_8H_{10}). These are all found in benzol as it is used for motor fuel. The term "aromatic" refers to the aroma, or odors of the members of this group, many of which have a rather pleasing odor. Chemically they are quite active, due to the presence of double bonds in the molecular structure similar to the olefines, though this activity is much less in this case due to the ring structure. Because of their activity and the abundance of distillates produced as by-products of the coke industry for many years, they have been studied more thoroughly than most any other class of organic compounds, and the abundance of dyes, perfumes, synthetic flavors, explosives, and other synthetic materials based on coal tar products, stand as a witness to this fact. They also show something of what can be done as a result of a correct theory as to the structure of a molecule, because this line of work, and in reality synthetic chemistry itself, started when Kekule postulated the ring structure of the benzene molecule.

The benzene ring is pictured as being composed of six carbon atoms joined together in the form of a ring with alternate single and double bonds, and each carbon atom having a hydrogen atom attached to it on the outside of the ring.

The aromatics are heavier in gravity for a given boiling range than any of the other groups here considered, and are best from the standpoint of anti-knock properties. In fact they are said to be non-knocking under any practical conditions of pressure commercially possible in the automotive engine.

If the reader cares to read more concerning the structure of hydrocarbon molecules from an elementary and practical standpoint he will find some very entertaining and instructive reading in a book called "Creative Chemistry," by Edwin E. Slosson, which may be found in most high school and public libraries.

The next important question in connection with the groups just studied is regarding their occurrence in the light distillates with which the treating plant operator is concerned, and the effect of cracking upon the different types of hydrocarbons.

The so-called "Pennsylvania" crudes are almost pure paraffin series hydrocarbons. The paraffin series also predominates in Mid-Continent crude, which is classed as mixed or intermediate base. These also contain some

naphthenes. Unsaturated, or olefine hydrocarbons are not found in crude oils. Naphthenes are found in considerable quantity in California, Texas, Gulf Coast, Mexican, Smackover, and some other fields. Aromatics are found in the same fields just named but are negligible in Mid-Continent and Pennsylvania crudes.

The composition of cracked distillates depends a great deal upon the cracking conditions and since there are so many types of cracking stills, a general discussion of some of the fundamental principles of cracking is opportune at this point. It is generally agreed that temperature is the most important factor in cracking so far as the breaking up of the hydrocarbon molecule is concerned. Both the amount and the rate of cracking are increased by increasing temperatures. Several investigators make the statement that the rate of cracking is doubled with each 10 degrees C. rise in temperature, after the cracking temperature is reached. The final form of the molecule, or in other words, the percentages of the different types of hydrocarbons found in the finished product, depends a great deal upon both the time of the reaction and the pressure at which it takes place. Cracking is ordinarily carried on for the purpose of increasing the amount of gasoline and with a given cracking stock there is an optimum temperature which gives the greatest yield. Bureau of Mines investigators state that this most favorable temperature does not extend over 50°C. for any oil. They also state that since most of the cracking takes place at the contact surface, the furnace temperature is really the controlling temperature. With increasing temperatures the gravity of the gasoline tends to become heavier for a given boiling range, due to the formation of hydrocarbons belonging to the heavier groups previously described. Also the percentage of fixed gases tends to increase with increasing temperatures if pressures and time of reaction are kept constant.

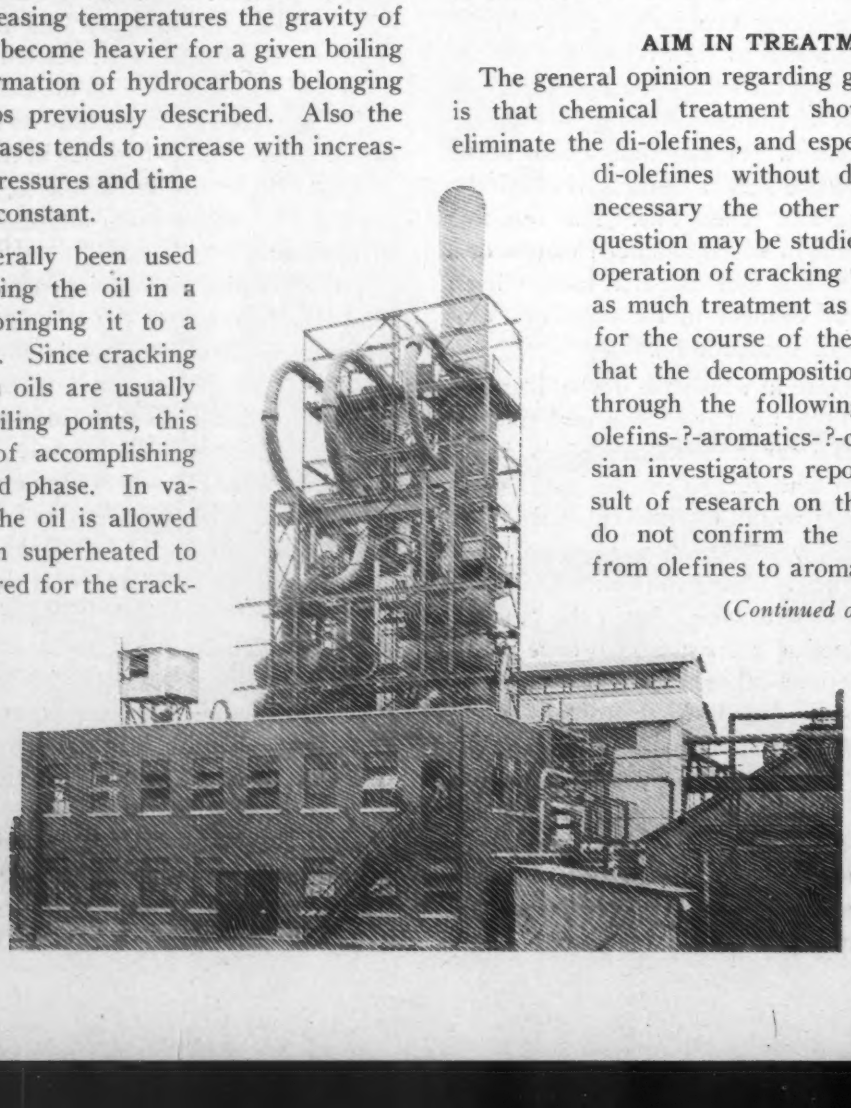
Pressure has generally been used as a means of keeping the oil in a liquid state while bringing it to a cracking temperature. Since cracking temperatures for gas oils are usually higher than their boiling points, this is the only means of accomplishing cracking in the liquid phase. In vapor phase cracking the oil is allowed to vaporize and then superheated to any temperature desired for the cracking reaction. Up to a certain point, other factors remaining constant, the yield of gasoline is increased by increased pressure, probably due to the fact that more compressed state of vapors favors formation of gasoline by what would otherwise be fixed gases. Higher pressures also result in gasoline which has a lower percentage of unsaturated, or olefine hydrocarbons. Some of the olefins formed in the cracking reaction are probably converted back to paraffins and some to aromatics, depending largely upon the character of the cracking stock and the particular conditions of temperature and time attending the reaction. Many think of the effect of pressure only in terms of the effect it has upon temperature or time, or both. For instance increased pressure keeps more of the oil in the liquid phase and this allows better heat transfer than is the case with a vapor, and hence not so long a time is required to do a certain amount of cracking at a given temperature. Many more of the apparent effects of pressure can be similarly accounted for as incidental to temperature or time.

The time factor in cracking is controlled by the rate of feed with respect to capacity of the still. Increasing time of reaction up to a certain point gives effects similar to that found with increasing pressures, indicating rearrangements in molecular structure following the original breaking up of the larger molecules, which are promoted by anything that brings about increasing contacts between the unstable molecules first formed. The percentage of olefines decreases with increasing time.

AIM IN TREATMENT

The general opinion regarding groups here discussed, is that chemical treatment should be such as to eliminate the di-olefines, and especially the conjugated di-olefines without disturbing more than necessary the other groups. The same question may be studied with respect to the operation of cracking units in order to save as much treatment as possible. One theory for the course of the cracking reaction is that the decomposition of paraffins goes through the following stages: paraffins-olefins-?-aromatics-?-coke and gas. Russian investigators reporting in 1928 the result of research on the cracking reactions do not confirm the step of progressing from olefines to aromatics but do conclude

(*Continued on page* 94)



White Star Plant Example of Compactness

By GEORGE REID
Associate Editor

WHITE STAR REFINING COMPANY, at its Trenton, Michigan plant, 17 miles from the center of Detroit, represents an excellent example of the modern compact and efficient refining installation. This skimming and cracking plant with its two 3000-barrel pipe stills, its 3300-barrel rerun unit and its two Dubbs cracking units, adequate working, crude, and permanent steel storage facilities, vapor recovery unit, continuous treating system, power plant, and other essential adjuncts to the modern refining scheme, is located on a site comprising 60 acres, and was erected and placed in operation during the first six months of last year. The original investment in plant, facilities and the like, is reported as $3,000,000. After nine months of operation the owners have found it necessary to enlarge the cracking department of the plant and accordingly are now installing a third Dubbs cracking unit and an extra reaction chamber for use in connection with the first battery of two units.

The two 3000-barrel pipe still units for skimming crude are similar in design and can be operated to secure gasoline, naphtha, kerosene, distillate, and gas oil as products of distillation. The overhead streams constitute about 50 per cent of the crude charge. The plant processes Mid-Continent crude secured by pipe line delivery. Fuel oil residuum is employed as the charging stock for the cracking units. The design of the distillation units follows in general the design of other Southwestern tube stills where employed to process similar crude oil. They are designed to secure efficient heat exchange and include auxiliary flash towers supplementing the work of the combination evaporator and fractionating column, with control being practically automatic.

The tube still units are very flexible in their operation and may be used to produce a number of fractions. However, under present practice the yields are confined to a gasoline fraction, consisting of all of the motor fuel content of the crude, and a 38/39 gravity 440 initial boiling point gas oil or stove distillate. Efficient fractionating is indicated by the end point of the gasoline cut which is around 425°F. The remainder of the crude is charged to the cracking units.

Crude enters the units through a reflux condenser at the top of the fractionating column which volume is under control and is employed to assist in the regulation of tower top temperature. After this the oil passes through a series of heat exchangers so manifolded that one or more of them can be taken from service for cleaning or repair without seriously impairing the efficiency of the unit. The exchanger series is split in two sections using two exchangers first, and after which the oil is flashed in the evaporator to return to the remaining exchangers before entering the tube still.

The pipe stills consist of 3½ inch I. D. tubes equipped with Tube Turn type of return bends. In the stills the crude is heated to about 550° F. and discharged into the combination evaporator and fractionating column. The oil is discharged above the stripping sections of the evaporator and the residumm flows downward to be accumulated and withdrawn through exchangers for moving to storage. Vapors pass upwards through the bubble tray sections of the rectifying column. This column is five feet by 54 feet in dimensions. Finished end point gasoline is removed as the overhead stream. A side stream of kerosene may be removed if desired and a lower side stream of gas oil, by means of the flash section provided for this purpose. The flash sections are provided with rectifying plates and with vapor lines for conveying the flashed vapors back into the side of the main bubble column. Their use is contingent upon the needs of the operators; for the operation is flexible and can be changed to meet practically any operating conditions. Closed type of condensers are used for all overhead streams.

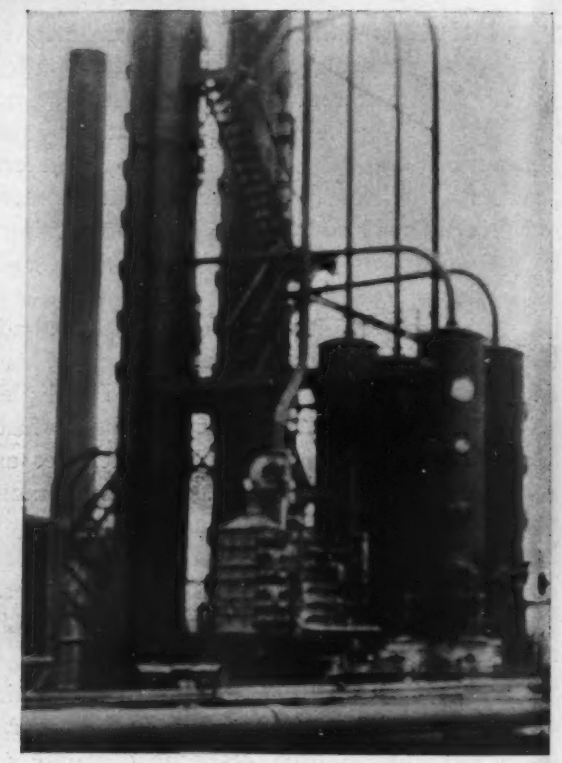
One main receiving house is used for the inspection of streams from both crude stills and for the streams from the rerun unit, which is located adjacent to the crude oil topping equipment.

PRESSURE DISTILLATE RERUN UNIT

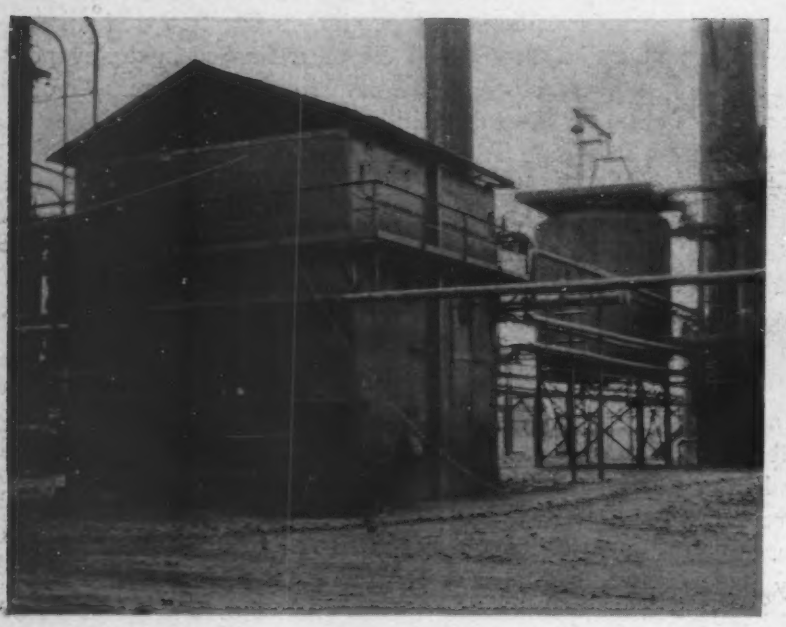
The rerun unit, which is designed to run 3300 barrels of pressure distillate from the Dubbs cracking units, is similar in design to the crude distillation equipment. Charging stock from storage passes through a reflux condenser at the top of the rectifying column and then passes directly to the still,

Plant White Refining

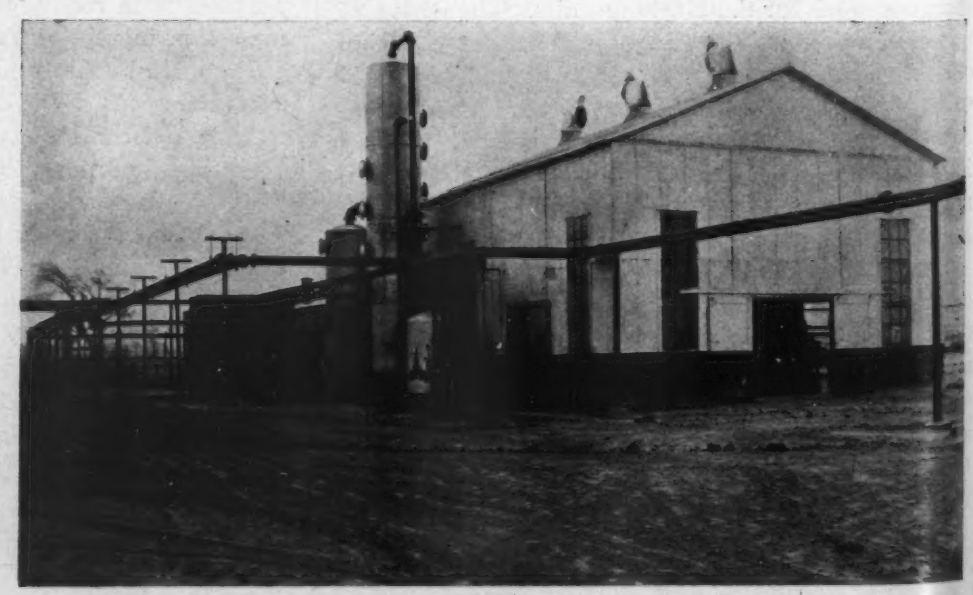
Residuum heat exchangers in series manifolded to allow one or more exchanger out of service for cleaning.



Fractionating equipment for two tube stills in compact layout.

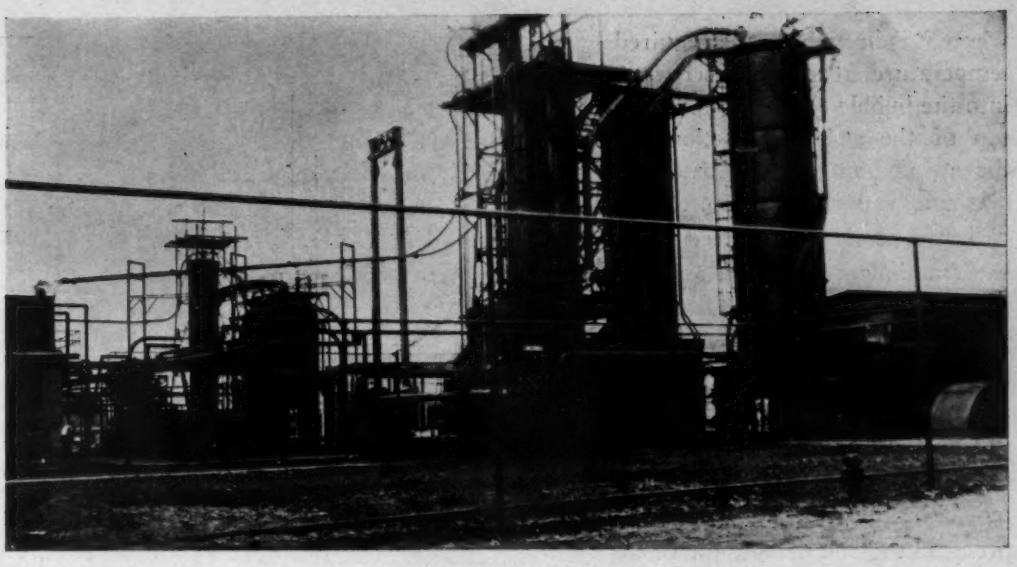


Above: Rerun unit of 3,000 barrels capacity and Gray vapor phase treating towers in series.



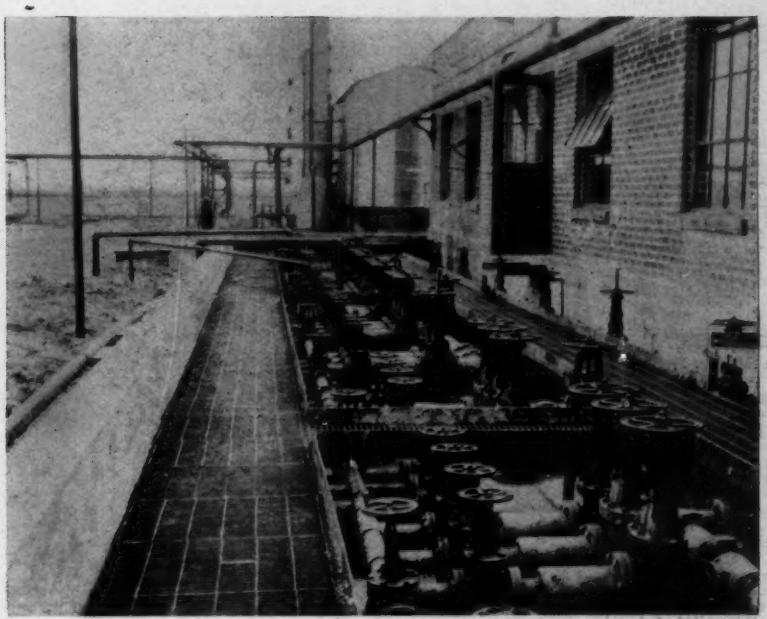
At Right: Vapor recovery plant handling a million cubic feet of refinery and cracking plant gases daily.

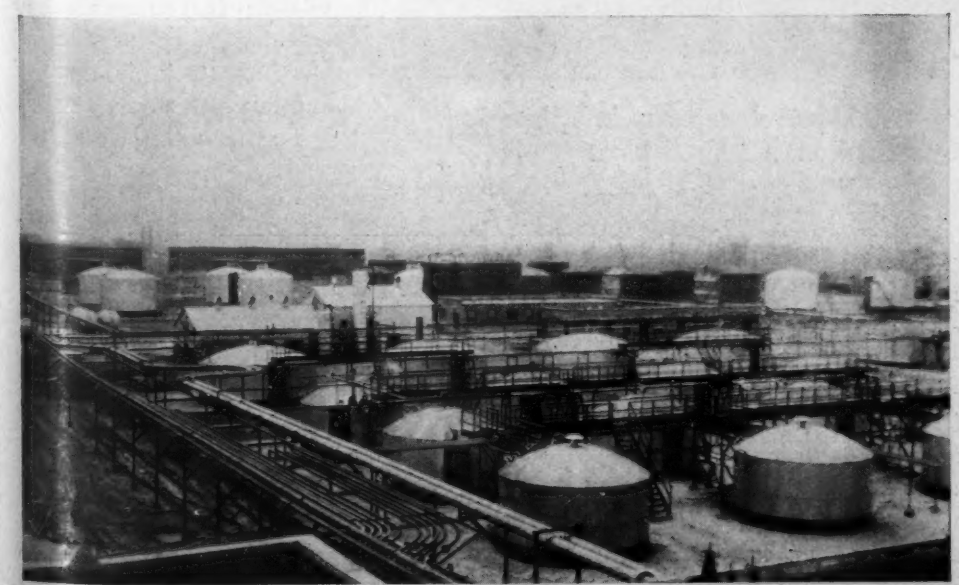
Layout Star Comyany



Cracking department with flashing equipment

All treating is done in continuous treating systems of modern type.

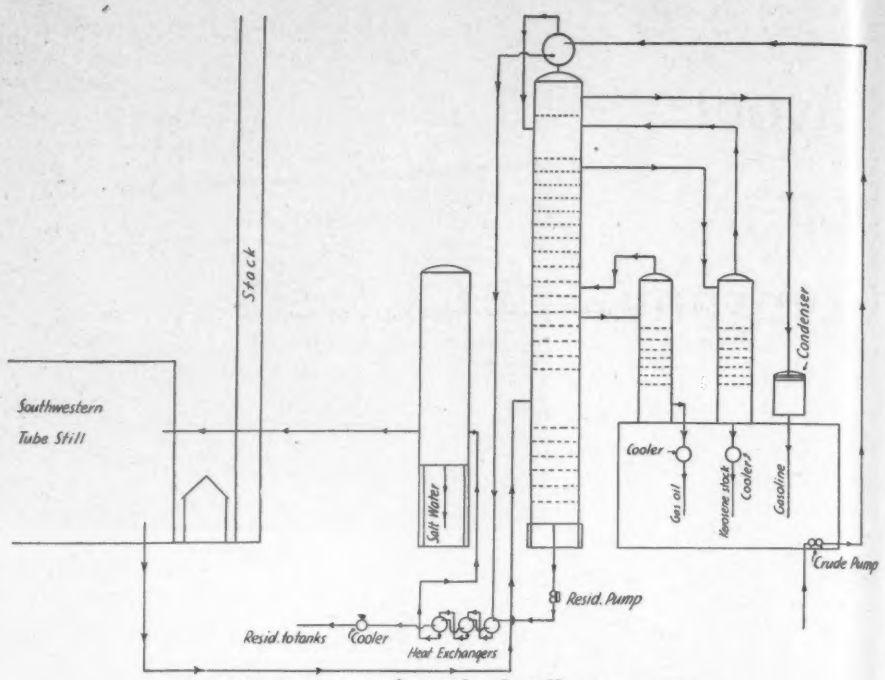




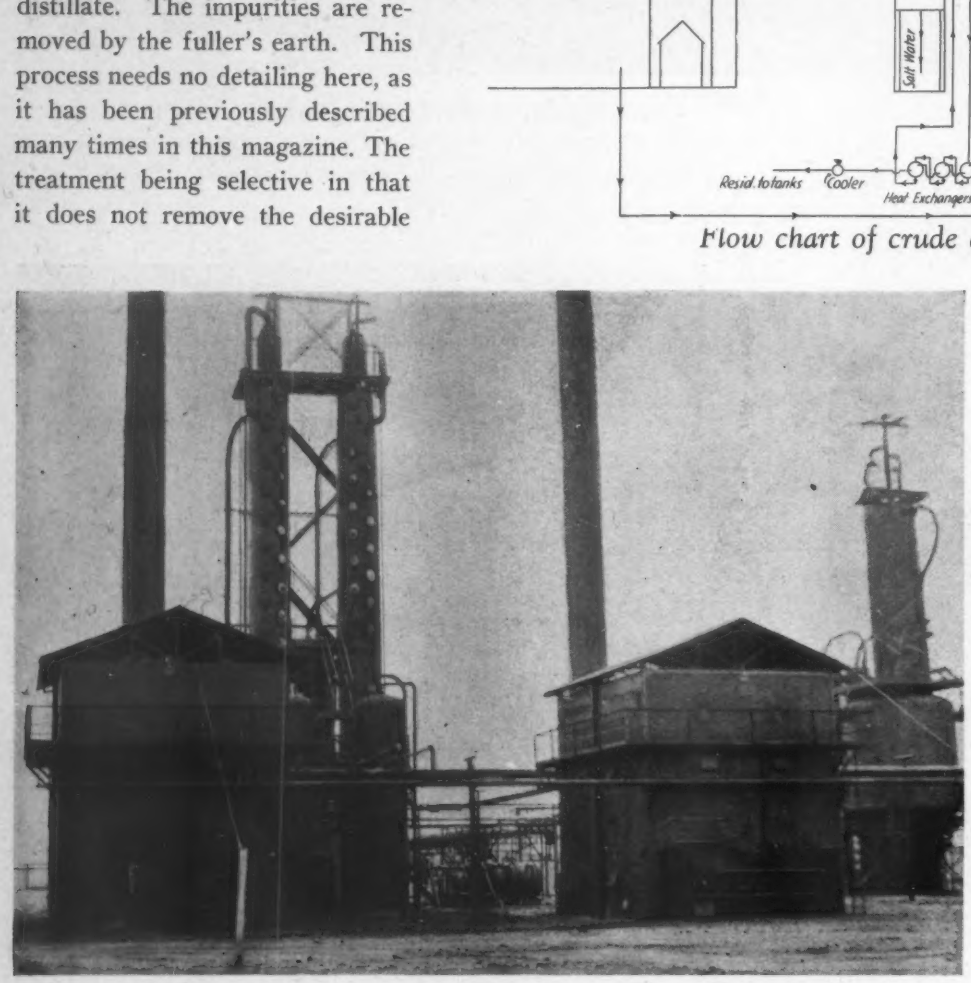
Above: View of Manifolds at main pump house arranged for convenience and safety.

Left: Safe steel walkways and guards are provided in convenient layout of run down storage.

where it is brought to the required temperature. It is then discharged into the bubble type column at the top of the stripping sections of the evaporator compartment Gasoline vapors under automatic reflux control are removed from the fractionating column and are passed through two Gray vapor phase treating towers hooked up in series. These towers effect a great reduction in chemical treating of the gasoline and pressure distillate. The impurities are removed by the fuller's earth. This process needs no detailing here, as it has been previously described many times in this magazine. The treatment being selective in that it does not remove the desirable



Flow chart of crude distillation unit



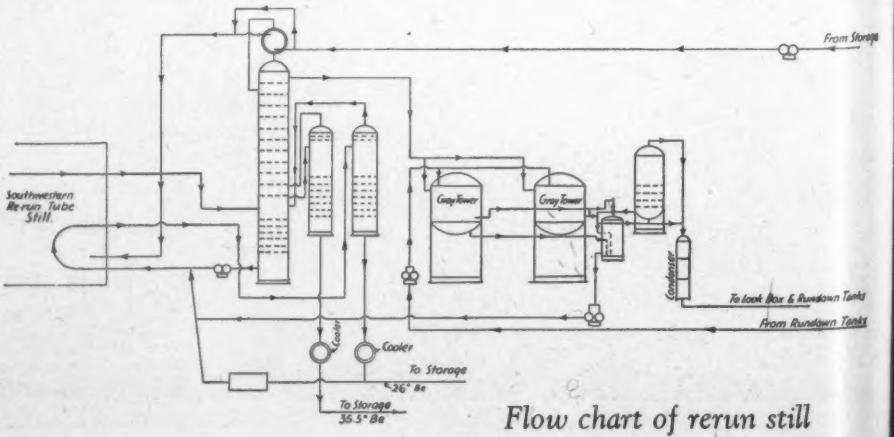
Twin crude distillation units of 3,000 barrels capacity at White Star Refining Company's Trenton, Michigan plant

aromatic hydrocarbons as chemical treatment does, is especially desirable since it tends to reduce the amount of tetraethyl lead required in the preparation of the company's Ethyl gasoline.

This installation was designed so that heavy condensate from the main towers is returned to an auxiliary flash tower where such condensate is stripped of any light ends present and these are returned to the main fractionating column.

Two flash towers are provided in connection with the return still to supplement the work of the main column. The main bubble tower is seven by 42 feet in size, while the flash towers working in conjunction with it are four by 16 feet in dimensions. In one of the flash towers a stream from the main tower is handled, returning the light ends to the large bubble column and the distillate from the bottom of the flash section which is suitable for furnace oil or cracking stock or fuel oil blending stock, is removed and taken to storage.

The second flash section



Flow chart of rerun still

is employed to flash the residuum that is removed from the evaporator section of the main rectifying column. This residue is first returned to the furnace where it is charged above the stripping section of the flash tower. The light vapors pass through a vapor line back into the main bubble column, and the heavy residue is removed for us as fuel oil blending stock, furnace oil or cracking stock.

TREATING

At this plant the Gray treating towers are employed to do their most effective work from the standpoint of actual treating of the gasoline rather than making an attempt to secure the utmost service from a given quantity of Fullers earth. Experimentation has shown, for example, that charges of 26 tons of earth handling 4000 barrels of gasoline is better economy than handling 8000 barrels of gasoline through the same quantity of earth, for the reason that the pressure distillate can be adequately treated with one pound of acid per barrel under such conditions and washed with doctor, which treatment suffices because of the efficiency of the Gray tower treatment. In addition, the gasoline produced under this method of treating requires only a slight caustic wash after the Fullers earth treatment. Also, the straight run gasoline produced requires only a caustic wash in the treating department. Obviously the less sulphuric acid required in treating the pressure distillate the better the grade of finished gasoline from an anti-knock standpoint.

The treating plant consists of four treating columns for pressure distillate treatment of one pound of acid and a sodium plumbite wash; two treating columns for caustic washing the cracked gasoline, and two columns for giving similar treatment to the straight run gasoline.

In the cracking department the Dubbs units are running to residuum. The flashed fuel, average eight to 11 gravity as withdrawn from the units is partially cooled through two-inch pipe in the cooler and is blended at once with 26/28 cracked bottoms from the rerun still. This practice has almost entirely eliminated the accumulation of b. s. and water in the finished fuel after it is stored. The flashed vapors from the residue are combined with pressure distillate and taken through the treating and rerunning processes for recovery of available gasoline.

Another interesting feature at this plant is its new vapor recovery system. About 1,000,000 cubic feet of gas are available daily from the cracking units, the crude and rerun still receiving houses and the light oil tanks about the plant yard. This produces 3000 to 4000 gallons of gasoline daily. The recovery plant is equipped with Chicago Pneumatic compressors driven by a General Electric synchronous motor, which compresses the low pressure gases and vapors and raised them to plant operating pressure of 60 pounds. The high pressure vapors from the cracking units are not compressed but pass directly into the Southwestern absorption plant system. In this installation all of the distillation equipment is placed inside of the plant building. The residue gas from this plant is conducted to the two 625 horsepower Springfield water tube boilers in the power house, and is burned as fuel. The gas fuel is supplemented here by very slow firing with coal by means of Detroit under-feed automatic coal stokers. The use of these gases has reduced the fuel costs at the power plant to a very large extent.

American Petroleum Institute Committees Meet

Members of the newly appointed division of refining committee on standardization of refinery equipment of the American Petroleum Institute met at the Stevens hotel, Chicago, at 9:30 A. M. Monday, June 9, for the initial organization meeting. The group's program for the annual meeting in November was discussed at this session.

Plans for that part of the program of the seventh annual meeting of the American Petroleum Institute pertaining to refining are also being developed and suitable papers are being solicited by the program committee. R. P. Anderson, secretary of the division, has requested that authors send brief summaries of their papers to reach him at institute headquarters, 250 Park avenue, New York, on or before June 21, 1930. The committee will hold a meeting shortly thereafter to agree upon the program, and authors will be notified promptly as to whether their contributions can be accepted for presentation at the annual meeting, which will be held at the Stevens hotel, Chicago, November 11 to 13.

The program committee, appointed recently by W. M. Irish, Atlantic Refining Company, Philadelphia, division chairman, has as chairman T. G. Delbridge, also Atlantic Refining Company. Members are: H. W. Camp, Empire Oil & Refining Company, Tulsa; R. A. Halloran, Standard Oil Company of California, San Francisco; R. E. Haylett, Union Oil Company of California, Los Angeles; E. W. Isom, Sinclair Refining Company, New York; N. E. Loomis, Standard Oil Development Company, Elizabeth, New Jersey; K. G. Mackenzie, The Texas Company, New York; Walter Miller, Continental Oil Company, Ponca City, Oklahoma, and R. E. Wilson, Standard Oil Company (Indiana), Whiting, Indiana.

Committee on standardization — Mark W. Daw, Shell Oil Company, San Francisco; C. H. Haupt, Standard Oil Development Company, Elizabeth, New Jersey; K. V. King, Standard Oil Company of California, San Francisco; W. D. Kinsell, The Pure Oil Company, Chicago; F. P. Risdon, The Texas Company, New York, and Walter Samans, Atlantic Refining Company, Philadelphia.

FOURTH ARTICLE

Design and Operation of Fractionating Columns

By I. N. BEALL
Chemical Engineer

VIEWED broadly, the function of fractionation is to effect separation between the absorbed components of natural gas and the absorption oil. The objectives are: oil-free gasoline, and completely stripped oil. Other requirements are that the absorption coefficient of the absorption medium shall show a negligible decrease per cycle and that the heat expenditure is kept to a minimum. The previous step of absorption and the subsequent step of condensation confine the conditions of fractionation to rather narrow limits of temperature and pressure.

As the repeated heating and cooling of the oil during each operating cycle causes rather rapid deterioration, high oil temperatures are to be avoided. On the other hand a high operating pressure is desired for the purpose of effecting condensation of distillate and this necessitates an elevation of temperature in direct ratio to the increase of pressure. High operating pressure is also desirable from the standpoint of the equipment involved as higher capacities are possible. This, however, should not be major consideration, as the original cost of a fractionating column is insignificant in comparison to the benefits derived or losses sustained in its operation.

THE BASIS OF CALCULATION

Calculations are based upon the oil plus its absorbed constituents. The saturation of the oil is best computed from the volume of gas absorbed, which is, of course, the difference between the volumes of inlet and outlet gas to the absorber. It is fortunate that the gaseous volume of the vapors is known, as the direct measurement is more accurate than the estimated volumes based on calculations from liquid volumes. As has already been discussed in a previous article on absorption, the molecular weight and specific gravity of these absorbed vapors can be determined by rather simple means, also the liquid volume and gravity estimated with a fair degree of accuracy.

The absorption plant operator has a more intimate knowledge of the nature of materials undergoing distillation than has the refiner of crude oil. Inasmuch as the specifications of the absorption oil are known, and as the number and characteristics of the natural gas hydrocarbons are comparatively few and simple, the computations for fractionation can be made more nearly quantitative than those relative to the fractionation of crude oil and distillates. It is possible to predict with reasonable certainty what the behavior of an enriched or saturated oil will be on distillation and what results may be anticipated.

The utility of the molal quantity is at once evident. The use of the mol-pound or mol-gallon establishes a relationship between liquid and vapor volumes, heat of vaporization, specific gravities of gas and liquid, and specific and latent heat requirements.

The heat required for evaporation can be approximated by Troutons rule - $\frac{Mr}{T}$ where M is the molecular weight, r the heat of vaporization per pound of liquid and T the boiling point in degrees absolute. Average figures are used and $\frac{Mr}{T} = 22$ is sufficiently accurate for most purposes. An added refinement to this rule is the Hildebrand function which states that this quantity varies with the molal concentration of the vapor evolved, which is of course determined by the pressure. A reference liquid such as hexane is used to determine the values of $\frac{Mr}{T}$ for two or more pressures from which a curve is drawn. These values are used in the formula. For example, if this value is 20 for a certain pressure of hexane, the heat necessary for vaporization of one lb. of pentane may be calculated as follows, taking 72 as the molecular weight of pentane and 98°F. as the boiling point. The boiling point of pentane for the corresponding pressure. $\frac{722}{460 + 98} = 20$; r = 155 B.t.u. per lb.

For mixtures of hydrocarbons the average boiling point and average molecular weight is substituted in the formula. Thus it becomes possible to estimate the

heat required for vaporization of absorbed constituents as the total number of pounds absorbed is computed directly from the difference in volume of the inlet and outlet gases to the absorber and their respective specific gravities.

Other heat requirements for fractionation are based upon the oil, the usual rapid method for such calculation is by taking the specific heat as 0.5 or half that required to raise the temperature of liquid water. It is also necessary to further supplement the heat requirements by the sum of the heat necessary to raise the vaporized constituents to the boiling point. For this purpose 0.65 is a better value. The specific heat in all cases increases with an increase of temperature;—for an absorption oil of 36.0 A. P. I. gravity, this value will be between .5 at ordinary temperatures to 0.7 at 400°F., so a better average value is 0.6.

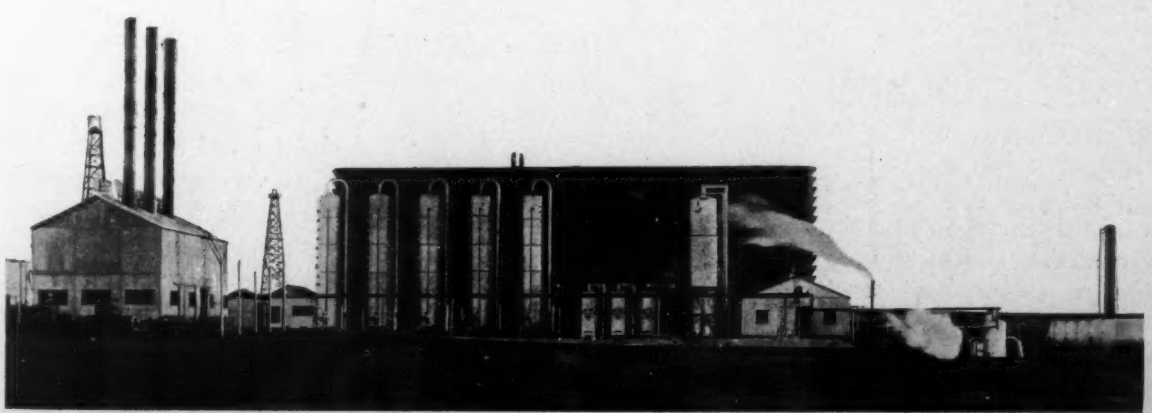
The total heat requirements in order to raise saturated oil to distillation temperature summarized as follows: $0.6\ (T_1 - T_0) \times$ lbs. Oil $+ 0.65\ (T_0 - T_2) + H =$ B.t.u. required where T_0 is the initial temperature of the saturated oil, T_1 is the final temperature of oil entering fractionating tower T_2 is the average boiling point of absorbed constituents at fractionation pressure, and H is the total heat required for vaporization, H in this case being equal to the sum of the latent heat of evaporation of the absorbed constituents plus the heat necessary to vaporize a portion of the oil in order to assure complete vaporization of the absorbed. The amount of oil vaporized has to be an experimentally determined quantity. Best values are obtained by the use of a true boiling point distillation. This quantity is greater as vaporization takes place. However, the vapor pressures of light oils is greater, so a lower temperature is necessary for separation, thus the total heat requirements are but little affected.

THE USE OF STEAM

Steam is used in fractionation for the purpose of lowering the temperature necessary for fractionation. The quantity used is dependent upon the volume temperature and characteristics of the materials to be separated as well as the design of the fractionating apparatus. The greater the saturation of the oil the less steam is required. Raising the pressure necessitates the use of additional steam, whereas a raise in temperature of the entering oil calls for a reduction in volume. Increasing the number of plates in a column of given design will cut down the steam requirements. Superheated steam is advisable, as a wet steam may cause a drop rather than an increase of temperature, due to the high latent heat of vaporization of water. The volume of steam necessary for a certain reduction in fractionating pressure can be estimated from a consideration of the partial pressures involved. Where a tower is operating at, for example, 30 pounds gauge and 350°F. and the volume of vapors is estimated at 3,000,000 cu. ft. the amount of steam necessary to lower the temperature of fractionation without reduction of pressure or loss of efficiency can be computed as follows: A vapor pressure curve of the saturated oil is required for the determination. The vapor pressure in pounds absolute is read for the corresponding temperatures, call these P_0 and P_1 and the absolute fractionating pressure P. Then $P - (P_0 - P)$ will correspond to the reduced pressure necessary. The additional steam necessary will be approximated by the formula $\frac{\text{Volume Vapors}}{P - (P_0 - P_1)}$ — Volume Vapors = Volume steam increase. In this example say $P_0 - P_1 = 10$ lbs. the calculation is

$$3{,}000{,}000 \times \frac{44.7}{(30 + 14.7 - 10)} - 3{,}000{,}000 = 882{,}000$$

The amount of water necessary to produce this volume of steam at say an operating temperature of 320°F., can be found from steam tables or by use of the formula $359\ \left(\frac{492 + T_1}{492}\right) \times \frac{8.34}{18}$ = cu. ft. of steam per gallon of water where T_1 is the operating temperature in degrees F. Water gives a large volume of vapor per gallon because of its lower molecular weight and its high density. Where steam is used as the stripping gas it is desirable to use the greatest permissible quantity consistent with the apparatus, as the lowest fractionation temperature possible is best from the standpoint of deterioration in the absorptive capacity of the oil. Too low temperatures, however, must be avoided, due to the possibilities of emulsifying the oil. Heavy oils are more subject to emulsification than light oils; dirty, oxidized oils are the worst offenders. Superheated



steam assists in obviating this difficulty, and the best assurance is an efficient reboiler at the bottom of the tower, beneath the stripping plates.

STRIPPING BY USE OF VAPORS

Vapors may be used to replace steam as a stripping gas, if care is used in the selection. All danger of emulsification is avoided and lower temperatures and pressures are possible. Where vapors are used as the stripping gas, compression before condensation is necessary in order to assure recovery. A subsequent stripping of the oil with steam is at times to be recommended for the purpose of oil conditioning. Where a low temperature stabilizer is used, the high partial pressure vapors are released from the high stage accumulator tank and only the overhead vapors from the stabilizer used for stripping. The volatility of these vapors is controlled by raising or lowering the high-stage accumulator pressure. Where high pressure fractionation is used for the gasoline, these vapors may be made to order by use of an additional column. Where recirculation vapors are used for stripping, a low-oil saturation consistent with efficient stripping of the gas in the absorption step may be used as for purposes of fractionation the stripping vapors may be expressed as equivalents of saturation. It is well to remember that for sharp separation between two mixtures one fractionating column is required, for every additional sharp separation an additional column will be required. The volume of vapors necessary for stripping are calculated from the existent partial pressure conditions. The methods used for absorption are applicable to fractionation.

DISPOSAL OF DRIP GASOLINE

Drip gasoline usually constitutes a considerable proportion of the total plant production. As this material comes into the separators it is usually discolored with oil and dirt so some means have to be provided for its renovation before sale. As drip is less volatile than the plant gasoline; the question is, should this material be pumped into the oil going into the fractionating column as is the custom in some plants? The best solution for this problem from the writer's experience, is to provide a separate fractionating system for this purpose and further supplement the drip passing through this system by the liquids from the various plant separators. The end-points of the finished gasoline can be controlled sharply by such procedure, and more even flow conditions maintained within the principal fractionating column by avoiding shots of drip resulting in vary load and upset equilibrium. Where drip is added to the saturated oil, more heat is required for separation, as the boiling range of drip falls closer to the boiling range of the oil than the more volatile absorbed constituents. Smoother operation and more uniform absorption oil and finished gasoline are possible where the drip is not added to the saturated oil. It is frequently found that the product from the auxiliary fractionating system is an excellent light motor fuel when stabilized. There is, however, an advantage from total plant efficiency in adding the distillate vapors from this system directly to the main product in the accumulator tanks before stabilization, as it will be found that at least an equivalent volume of butane may be used without exceeding the vapor pressure requirements of sales specifications. This is an important consideration where there is an excess of butane above the requirements. Usually it will be more advantageous to mix the drip and heavy ends from the knockouts into the main product, after they have passed through the auxiliary fractionation, unless double the price of the main product is obtainable.

An auxiliary fractionating system gives flexibility to plant operation, as all danger of high end point or oil discolored gasoline is avoided. A hot knock-out can be used between the fractionating column and the condensing system. With the temperature of this knock-out under automatic control, the fractionator can always be run close to the danger line without spoiling the product. The bottoms from the auxiliary fractionator can be returned to the stripped oil, making up for what otherwise would be lost in the form of gasoline end-point and as light ends from the oil.

SIZE OF THE FRACTIONATING COLUMN

Inasmuch as the minimum oil temperature necessary for separation is advisable, considerable care should be exercised in the selection of the correct size as, other things being equal, the temperature requirements go up with the size of the tower. The smallest diameter column that will do the work is best. The same principles apply to fractionator design as apply to absorber design, but there are additional considerations involved. For purposes of discussion the portion of the tower above the oil inlet will be referred to as the upper section, and the portion below this point as the lower section. The upper section consists of the fractionating or reflux plates and the reflux zone; the lower section contains the stripping plates and the reboiler, also provision for the injection of stripping gas, such as steam.

The mixture enters the tower in a partially vaporized state. The proportions by liquid volumes of oil to vapor is relatively great, therefore a heavy liquid load and a light vapor load is thrown onto the stripping plates. As the fractionating plates primarily receive only vapors, all liquid on these plates is due to condensate. This condensate consists of liquid formed in the passage of the vapor from plate to plate and the liquid from the reflux condenser or forced reflux. All of the vapors, with the exception of the outlet vapors, must be condensed and returned as liquid to the first stripping tray with the exception of the liquid held up by the plates. The liquid load for the stripping trays thus consists of all condensate plus all unvaporized oil. The vapor load for the stripping plates is that of the stripping gas plus that formed from the oil by the addition of stripping vapors and reboiling.

All vapors pass into the upper section so the vapor

load is heaviest on the first fractionating tray. The liquid load is heaviest for the upper section on the tray just below the reflux condenser, or the tray receiving the forced reflux. When operating correctly a rather delicate equilibrium is established between reflux, condensate, vapors, oil and stripping gas. Towers of large diameter require more energy in the form of heat to attain this condition of equilibrium. Formulae for the calculation of liquid and vapor flow were given in a previous article on the design of absorption plates, these formulae are applicable to fractionating columns. Here, as in absorption, the tendency to "puke" is the limiting factor in capacity. The trays in the lower or stripping section should be larger or have greater liquid overflow area than the fractionating plates in the upper section. On the other hand, greater vapor passages should be allowed for in the fracitonating plates. Here it may be added that it is better to build towers of greater length with more plates, than it is to attempt to attain efficiency by the use of shorter towers of greater diameter and less plates.

As the number of plates in a tower decrease for a given plate design, the amount of reflux necessary increases, heat efficiency is lost, higher oil temperature is required. Heat energy should be made to do useful work in separation. This is done by the plates. Separation could be effected by the use of reboilers and reflux condensers working in conjunction without plates, but the heat requirements and losses would be high. On the other hand, separation could be effected by the use of sufficient plates without a reflux condenser, but the cost of construction would be prohibitive and the flexibility of operation nil. The quantitative analysis of fractionator design is too involved to go into detail here, and will be taken up more thoroughly in a subsequent article. The problem is a subject for mathematical and graphic analysis.

INSULATION OF FRACTIONATING COLUMN

A logical question frequently asked by natural gasoline plant operators is, why is it necessary to insulate a fractionating tower, inasmuch as cooling has to be used in the form of reflux condensers, or forced reflux to the top of the column? Why not let atmospheric temperature provide part of the cooling necessary for reflux? The answer is that the reflux liquid should be supplied from the top plate of the column, rather than from the reflux in form of condensate between plates. Considering the original saturated oil as a two component mixture, one component as the oil, the other the absorbed hydrocarbon mixture. As this mixture comes on to the first stripping tray, the absorbed fraction and a portion of the oil is vapor, and as such ascends to the next plate, where a portion comparatively rich in the heavier constituents is condensed.

The vapors are further supplemented by that from the stripping plates produced by the injection of stripping gas and reboiling which of itself adds to the total vapor. As the vapor passes up through the successive fractionating plates, the performance of condensation and revaporization is continued until the final mixture which is rich in gasoline hydrocarbons but poor in light ends of the oil, reaches the zone of cooling or reflux. from this reflux zone a mixture rich in the heavier portions of gasoline is condensed together with the remaining oil ends, which mixture descends downward through the plates where progressively less volatile constituents are vaporized. The vapors are always richer in the more volatile component than the liquid from which they distill, therefor if a mixture such as that supplied by a reflux condenser is supplied to the top tray an equilibrium is established where only the lighter component will pass as vapor from the column. This is also the reason that, where forced reflux is used, the finished product is best for the purpose. From this foregoing discussion it is immediately evident that an increase in the number of plates results in increased flexibility of operation because of the provision for wider variation in the zone of equilibrium, that is variation in the amount of reflux will not force the lighter component back into the stripping section, nor will an increase in temperature or vapor from the stripping section cause heavy ends to be carried through the zone of equilibrium which exists on the top trays.

The average heat loss through an uninsulated metal surface at an operating temperature of 350°F. amounts to approximately 600 B.t.u. per hour per square foot of surface exposed, which for a six-foot by 30-foot tower is 8,640,000 B.t.u. per day, which is sufficient to heat 10,000 gallons of oil from 150°F. to 350°F. The saving in heat alone is worthy of consideration.

REBOILING

The more efficient towers use a reboiler beneath the stripping trays. The reason for this is to have the oil leaving the tower hotter than the oil entering so that the gradient on the stripping plates will be up instead of down. This difference should equal at least 2°F. per plate or where there are five stripping trays the oil leaving

This constitutes the fourth of a series of articles by I. N. Beall dealing with the practical application of technology to the manufacture of natural gasoline.

The three previous articles dealt with "Securing Maximum Recovery From Absorption", in the issue of March; "Absorption and Absorption Oils" in the issue of April, and "Factors Affecting the Operation of Absorption Equipment" in the issue of May.

the fractionator should be at 10°F. higher temperature than the incoming mixture.

The principles of fractional distillation are based upon a progressively increasing temperature difference between trays from top to bottom, otherwise absorption rather than distillation effects would result. Where superheated steam is used the reboiler is sometimes dispensed with, however, it is better practice to use both. The drop of temperature through the stripping trays is in a major degree occasioned by loss of heat to produce vaporization. This heat, lost as latent heat of vaporization is best made up for by the use of a reboiler.

WATER SEPARATORS

Where steam is used for stripping a portion will condense out in the tower and provisions will have to be made for its removal. The greater portion of the water will come from the reflux section, but some condensation will take place in the upper fractionating trays. Water, because of its greater liquid weight and its immiscibility, can be separated by the use of liquid level separators. Two separators are necessary, one for the first and second top plates, and one at the lowest likely plate where steam will condense. The selection of this point of separation can only be determined by a knowledge of operating conditions. If liquid water drops back into the stripping trays of the fractionator, bumping is likely to occur and the entire equilibrium of the tower ruined. There is always danger that the entire contents may be discharged over the top. It is of interest here to note that when a tower bumps, the oil from the stripping section discolors the discharge.

TROUBLE SHOOTING

Difficulties are bound to arise in the operation of fractionating equipment. Considerable skill and experience is necessary in order to find the source of the trouble and apply the correct remedy. The most frequent difficulties are as follows: (1) the end-point of the gasoline is too high, (2) the oil is not stripped, (3) the oil is losing its absorptive capacity and, (4) the still is bumping.

The procedure for number one is first, to increase the amount of reflux. If the trouble is not entirely remedied by this change, the volume of stripping vapors or steam should be gradually decreased. Abrupt changes are to be avoided as delicate equilibrium conditions within the column are easily upset. One variation at a time is the way to proceed, holding whatever advantage gained. If the above two changes have not produced the desired results, the final procedure is to slowly raise the oil temperature in the column and intermittently increase the amount of reflux. If all attempts fail, drip-gasoline may be added to the saturated oil.

It is a matter of common observation that high end-point is most likely to occur when the absorbed hydrocarbons average the greatest volatility. The higher the partial pressure of hydrocarbon or hydrocarbon mixture, the greater capacity for carrying heavy vapors. This is true for both absorption and distillation.

Where it is found that the oil is not stripped, the amount of reflux should be decreased, unless the end-point of the gasoline is close to the danger line. Next the amount of stripping gas should be increased, following which it may be necessary to decrease the inlet oil temperature. The final remedy will probably be to decrease the oil inlet temperature. The best combination of all changes have to do with minimums of temperature, stripping gas, and reflux. If a decrease of pressure is permissible better stripping will result.

Where it is found that the oil is rapidly losing its absorptive capacity, immediate remedies must be applied. Sludging of the oil is likely to occur and pyrogenetic and oxidation changes, will increase the gravity and lengthen the distillation range. The temperature of the oil must be decreased, and stripping effected by other means, such as increase in stripping gas, decrease of reflux, or reduction in pressure. The writer's experience is that the danger point is around 320°F. for most oils and that 300 to 310°F. is a better operating temperature from the standpoint of the oil. If it is possible to retain absorptive afficiency, a higher oil saturation may remedy the trouble and permit a lower operating temperature. Carefully selected recirculation vapors may be added to assist in stripping at lower temperatures.

Under trouble number four, where the still is bumping, the water separators should be examined to see if they are working properly. Next, if permissible, the amount of steam should be increased, or the operating pressure reduced. If water is found in the stripped oil, the reboiler temperature should be increased. The best remedy would be to increase the amount of vapors by use of drip in the saturated oil or supplement some of the steam by stripping vapors. A decrease in oil inlet temperature may solve the problem. The advisability of a secondary fractionating system for a drip and knock-out liquid is apparent from the foregoing, as in a final analysis, the problems of natural gasoline plant fractionation hinge on the stripping of the oil and the end-point of the gasoline. Lighter absorption oils may be used, with fear of contamination of the gasoline eliminated and complete stripping of the oil assured.

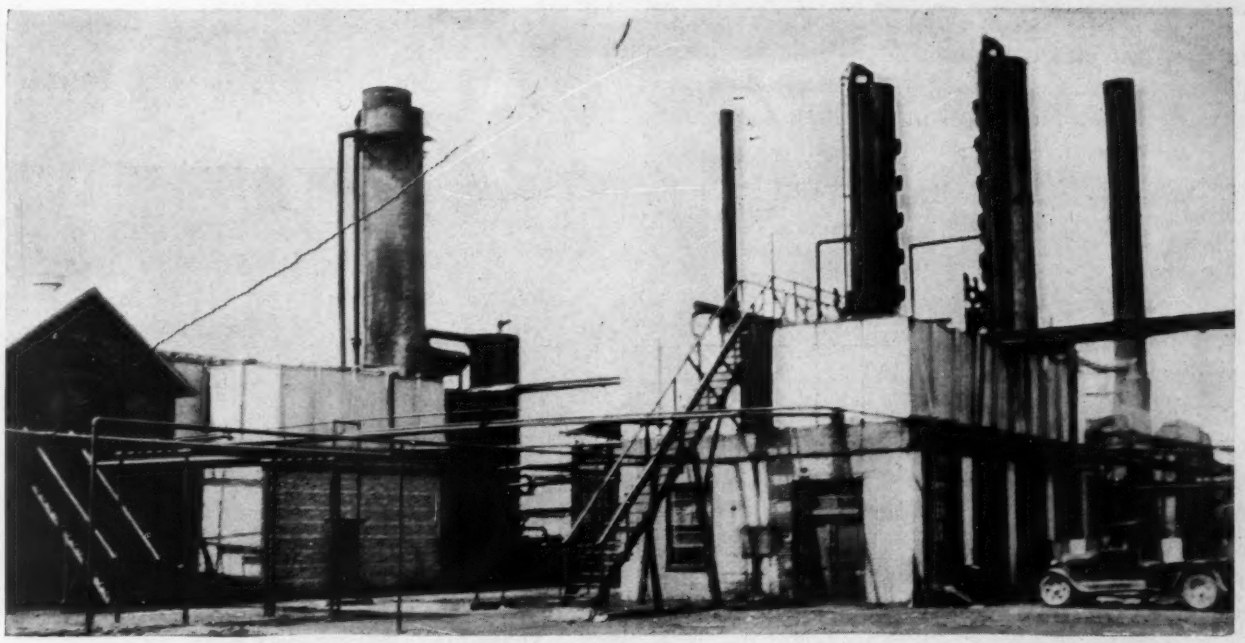
CORRECTION

In I. N. Beall's article Number 3 "Factors Affecting Operation of Absorption Equipment" appearing in REFINER AND NATURAL GASOLINE MANUFACTURER, issue of May, 1930, page 90, column one, paragraph three, the text should read as follows: "Depth of liquid seal is dependent upon the pressure drop per plate and is figured at maximum gas capacity. The depth to which liquid will be backed up in the down-drain, or underflow, can be computed from the formula $H = \frac{V^2}{2gc^2}$ where H is expressed in feet of vapor at absorber pressure."

Old Plant Re-Designed Meets Modern Requirements

By GEORGE REID
Associate Editor

WHEN Globe Oil & Refining Company took over Lamont Refining Company's old plant in May, 1929, it was necessary for them to modernize practically every department of the plant and to effect increases in capacity of all essential equipment in order that the plant might serve the purposes of the new owners.



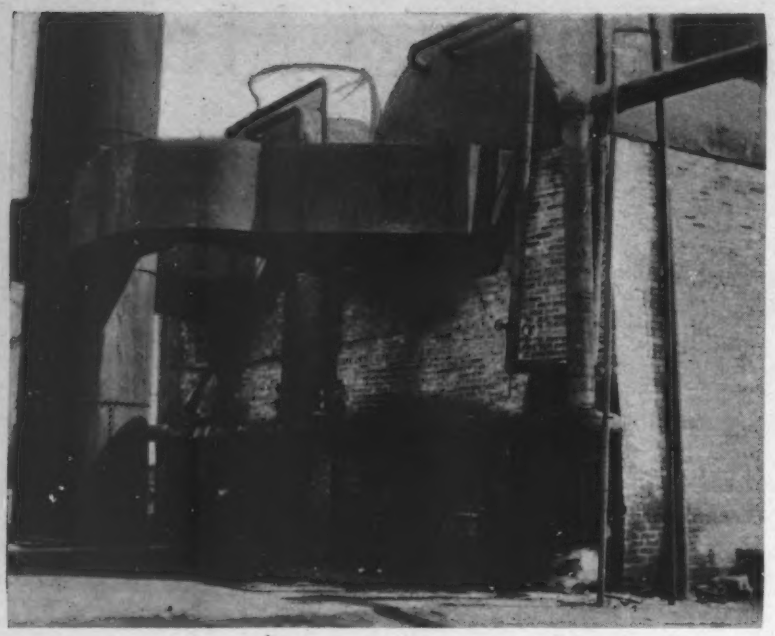
Globe Oil & Refining Company at Lemont, Illinois has completely rebuilt the eight year old plant employing modern fractionation, condensing and heat exchange equipment

This plant was originally built by Shaffer Oil & Refining Company (now Deep Rock Oil Corporation) in 1922, as a skimming plant of 1000 barrels daily capacity, running Kansas crude delivered to the plant by tank car. Two shell stills, baffle towers, and a batch agitator comprised the original plant. In 1927 a tubular retort with two evaporator towers and one bubble tower was added to the plant. This, primarily, comprised the equipment at the refinery when Globe Oil & Refining Company purchased the property last year.

Before operation the plant was thoroughly reconditioned and modern improved equipment placed in service while at the same time revamping as much as possible of the older facilities available. Winkler-Koch Engineering Company was called in to modernize the equipment. D. B. Kelly, for many years in charge of refinery operations at Wichita Falls, Texas, for American Refining Company, was placed in charge of plant operations.

One of the first undertakings was the revamping of the two old shell stills. These were raised considerably on their setting and the furnaces were redesigned and rebuilt. In these 10 by 40 feet shells there was installed 64 three-inch tubes in the bottom half of each still in the usual manner such as has been described in this magazine several times. The stack was moved from the front to the rear of the still, thus giving the hot gases of combustion two passes, once from the fires back along the bottom sheet and then from back to front as the gases pass through the 64 tubes placed below the oil level in the stills.

New condenser boxes were provided and increased condenser section area installed to handle the additional capacity of the shell stills. New and larger condenser equipment was also provided for the pipe still. Improved modern bubble decks were installed in the pipe still bubble towers, and another tower added. The towers on the shell stills were replaced with modern bubble type equipment six feet by 30 feet in size. Pancake coils for preheating crude entering the system were installed in the upper sections of three of the

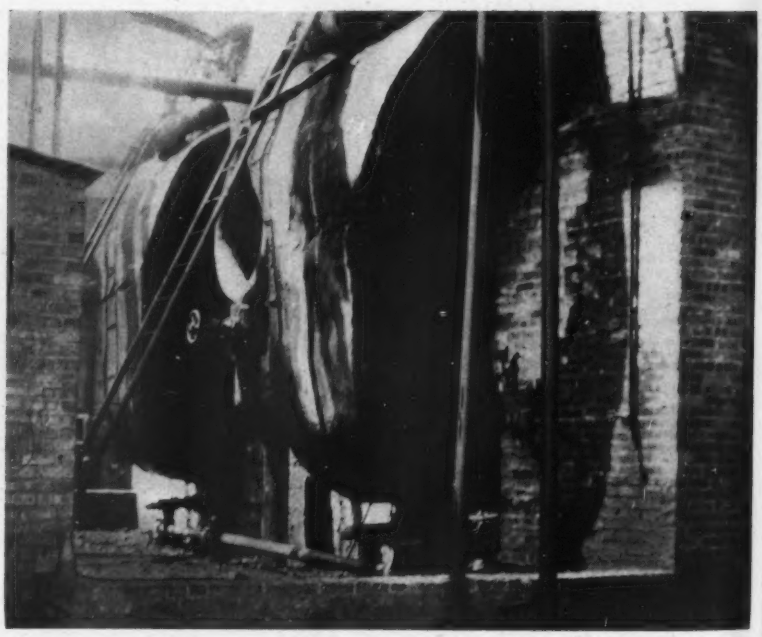


View of front end of rebuilt shell stills showing means of conveying hot gases to stack from internal flues below the oil level in the stills

towers. Four Griscom-Russell residual heat exchangers were added and one vapor-to liquid exchanger was placed on the stove distillate or gas oil vapor line. In the treating department a new continuous treating system consisting of six treating towers, six feet by 30 feet in dimensions, was installed. This department is again to be enlarged soon through the installation of three more towers of the same size, since the plant will need facilities for acid treating pressure distillate upon the completion of a combination skimming and cracking unit of 6000 barrels capacity now under construction.

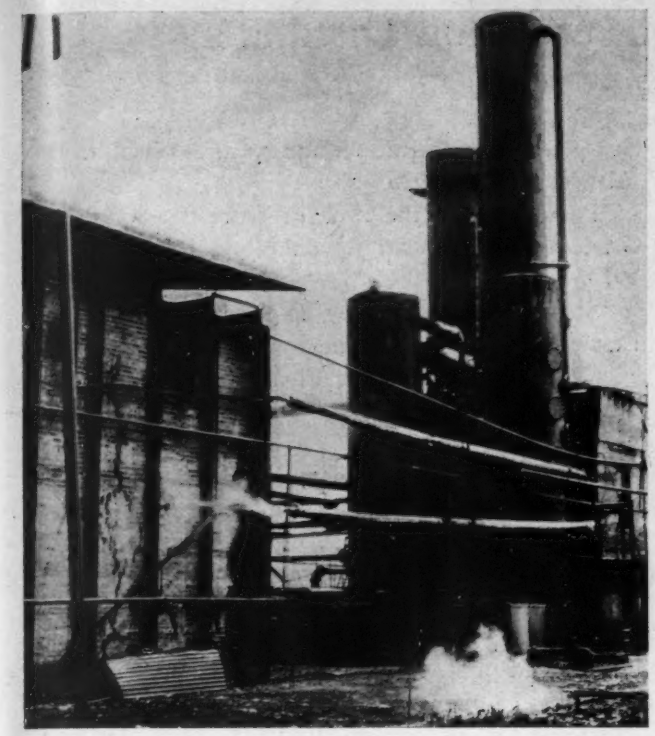
CRUDE SYSTEM

Cold crude entering the system is charged through the series of pancake coils in the tops of the two shell stills and the one pipe still bubble towers, and then passes through the series of G-R heat exchangers. This equipment preheats the oil to 250-275 degrees F. From the exchange system the crude passes into the evaporator. At this point a factor of operation is injected into this particular system which is a departure from the usual practice. The preheated oil is not hot enough at this point to effect the volume of distillation desired by the operators, and instead of injecting superheated steam, open or closed, or installing additional exchanger equipment, or both, the design calls for a portion of the bottoms of the evaporator to be circulated through one bank of tubes in the pipe still. This practice has the advantage of assured flexibility of operations at this point in the system, for through control of the circulation of oil from evaporator to still and back into the evaporator, as much or as little of the gasoline content as is desired may be liberated in the evaporator to be fractionated by the bubble tower working in conjunction with the evaporator. To secure 375-390 end point gasoline off of the evaporator the bottoms from this vessel were being circulated to the point where evaporator-bottom-temperature was held between 375 and 400 degrees F. Through the use of Brown control devices regulating this part of the system the control is more accurate than is indicated by the above temperature figures, naturally, but they are given to indicate temperatures required when crude to the unit shows some slight difference in gasoline content over a period of time. Whether or not it is more costly to utilize the tube still bank of tubes in this manner to secure the desired temperature in the evaporator bottom, and secure the desired flexibility of control of this part of the system, is a matter of speculation, it is believed, although no heat balances have been run on the system. Naturally, the stream of gasoline derived from this first heating varies with the requirements of the owners. Usually it is 62/64 gravity, 375 end point, or a gasoline of similar type.



Rear end of rebuilt shell stills showing means provided for returning gases of combustion into 64 three inch internal fules

The finished bottoms from the evaporator pass into shell still No. 1 and from there to still No. 2, where the product is 48/50 gravity, 290 initial, 410 end point gasoline from the bubble tower of the first still, and 44/46 gravity, 440 end point naphtha from the bubble tower on the second shell still. The temperature of the



Section of the evaporating and fractionating equipment working in conjunction with the heat exchange system and the pipe still

charged oil is raised to about 550 degrees F. in the operation of the shell stills.

Bottoms from the shell stills pass into the radiant bank of the pipe still where the temperature is raised to 650 degrees F. and from which it is discharged into a second evaporator. Fuel oil residue is withdrawn from the bottom of this evaporator averaging 18/20 A. P. I. gravity. From the tower working in conjunction with this part of the system a bottom stream of 32/34 gravity gas oil is removed, while a 41/43 kerosene stock is removed from the fractionating section above.

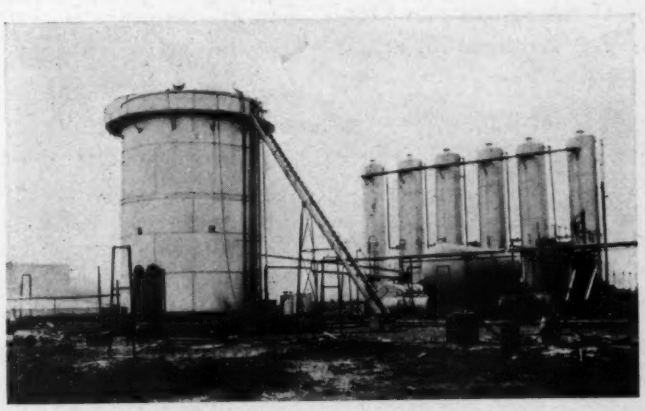
Former practice before the installation of the new bubble tower working in conjunction with the radiant tube-bank-evaporator part of the system involved only the use of the evaporator from the bottom of which a somewhat lighter fuel oil residue was removed, and a 36/38 gravity gas oil or stove distillate stream taken off overhead. The new tower inserted in the system at this point makes possible the removal of a better gas oil or distillate stream and also the recovery of an excellent kerosene. This product is easily handled in the treating department since the crude now processed is Mid-Continent grade oil whereas the plant formerly operated on Michigan crude.

The treating department consists of a batch agitator and a continuous treating system comprised of six treating columns. This is being enlarged and rearranged to care for the treatment of pressure distillate, straight-run and cracked gasoline. At present but a portion of the system is employed for the reason that gasoline produced from the sweet crude requires only a caustic wash to sweeten. A pump takes split suction, drawing gasoline from storage and caustic solution from one of tank-car tanks employed for chemical storage. The caustic and gasoline solution is then pumped through four vertical lengths of pipe in series, each of which is fitted inside with 20 disks of vane type which effect a whirling motion as the stream is forced against them and secure intimate contact between gasoline and reagent. From the mixer the solution enters the settling drum or tower, where the alkaline solution is withdrawn. In the next tower the gasoline is washed, then settled and run to storage.

Water for treating purposes and for boiling consumption is secured from a water well on the plant yard which was drilled to 1340 feet and produced about 400 gallons per minute, being pumped by a Peerless electric driven water-well pump. Boiler troubles are mostly unknown at this plant because of the excellence of the water, and boilers can be run 60 days to be taken down and washed clean without ratting tubes and the like. Two new 300 horsepower Vogt, three drum boilers have been installed.

The plant is exceptionally well located on two railroads, one on each side of the property, and within 1200 feet of the drainage canal where a dock has been built for loading oils in barges and the like. Pipe lines for different products connect the refinery with the loading dock. Water from this canal is also available for cooling purposes at the refinery. There are two loading racks of 24 car capacity at the plant, one of which is being enlarged to 34 cars capacity at present.

In the main pump house there are five belt-driven eight by 10-inch Gardner piston type pumps driven by electric motors. These pumps were on hand at the time the company took over the property but their capacity had to be increased through the installation of larger transfer lines. An electric driven two-stage Sullivan air compressor is housed in the pump house, and provided compressed air for the various needs about the plant yard. A total of 450,000 barrels of steel tankage is provided on the site.



Treating department for gasoline and kerosene refinement. The continuous treating system is being enlarged to handle pressure distillate and cracked gasoline as well as straight run motor fuel

Chemical Treatment of Petroleum Distillate

(*Continued from page 80*)

that coke is largely formed from condensation of aromatics. They further report the nature of the cracking reaction on the different groups found in crude oil as follows: Paraffins yield olefins and lower members of the paraffin series; the naphthenes react along two different lines. In the first place the side chain is broken down and in the second place hydrogen is evolved and aromatics formed. The aromatics have two characteristic reactions. In the first place, condensation products are formed and in the second place the side chains are broken down.

The widest divergence between cracked distillates from different types of cracking is that found between liquid phase systems and vapor phase systems. The heavier hydrocarbons predominate in gasoline from the vapor phase cracking. At temperatures around 950 to 1050°F. olefines are the chief product. Following is a typical analysis of gasoline produced from Cabin Creek crude by the Gyro Process: naphthenes 15 per cent; olefines 50 per cent; aromatics 35 per cent; paraffins 0. At higher temperatures larger percentages of aromatics are produced. At 1400°F benzol and tolual are produced in substantial quantities. Vapor phase cracking is in the ascendency at the present time but will probably never completely displace liquid phase cracking but be used in connection with it for increasing antiknock qualities in gasolines.

The treating plant operator, or even the chemist in the laboratory may not know the exact composition of their cracked distillates, but a general knowledge of the characteristics of different types of cracking equipment may be helpful in accounting for changes in operating requirements where several types are used. Eventually this may be worked out to a point where more careful control may be exercised with respect to removing undesirable products with a minimum loss of the desirable ones.

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"History and Efficiency of Cracking Methods," by George A. Burrell, Refiner and Natural Gasoline Manufacturer, March, 1925.

"Possibilities in the Low Pressure Cracking of Low Grade Fuel Oil," Carl J. von Bibra, Refiner, October, 1924.

"Some Facts Concerning Vapor Phase Cracking," by Luis De Florez, The Refiner, January, 1928.

"Cracking in the Vapor Phase," by Auld, Petroleum Times, January 19, 1929, p. 99, and January 26, 1929, p. 158.

"Gas Formation in the Cracking Process," by Egloff and Morrell, Industrial & Engineering Chemistry, Volume 17, No. 1, January, 1925.

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"Distillation of Gasoline Under Pressure," Ginsberg, The Refiner, October, 1927.

"Thermal Decomposition of Ethane, Ethylene, Propane and Propylene," Frey and Smith, Industrial & Engineering Chemistry, Volume 20, No. 9, September, 1928.

"Reports of Investigations," Department of Commerce, Bureau of Mines, N. A. C. Smith, Serial No. 2806, May, 1927.

"Hydrocarbons Occurring in Commercial Gasoline," George Reid, The Refiner, June, 1927.

"Composition of Petroleum and Its Products," George A. Burrell, Industrial & Engineering Chemistry, Volume 20, No. 6, June, 1928.

"Pure Hydrocarbons from Petroleum," G. G. Brown and A. R. Carr, Industrial & Engineering Chemistry, Volume 18, No. 7, July, 1926.

"The Composition of Mid-Continent Petroleum," Charles F. Mabery, Industrial & Engineering Chemistry, Volume 18, No. 8, August, 1926.

"Composition of Natural Gas Gasoline," Anderson and Erskine, Industrial & Engineering Chemistry, Volume 16, No. 3, March, 1924.

"Modern Refining—Science and Practice," George A. Burrell, National Petroleum News, Series beginning November 20, 1929.

Specifications and Blending Important Convention Topics

By GEORGE REID
Associate Editor

THE ninth annual meeting of the Naural Gasoline Association of America, held at Tulsa, May 20 to 22, may be classed as one of the most important conventions of this group. The valuable work of the gasoline manufacturers during the past year or two dealing with its products, the intelligent application of these products in their sales fields, and the study of specifications requirements of its principal product, was interestingly presented to the membership and visiting refiners in a series of valuable writings. This work adds much to the technical literature of the natural gasoline industry. Further, the work of the association this year provides the major consuming industry with much specific and concrete material for guidance in the utilization of natural gasoline in motor fuel blending.

Proceedings of Natural Gasoline Association

The purpose of the sessions this year was two-fold. First, much effort was expended toward the determination of specifications for proposed new gradings of natural gasolines, and secondly, much study was given the problem of intelligently blending natural grades with refinery distillates. Out of the efforts of the various committees and workers concerned in the important problems of the industry has come valuable additions to former practice and definite, concrete information directly applicable to the operation problems of both refiners and natural gasoline manufacturers.

Frank L. Chase, Lone Star Gas Company, chairman of the first morning session, opened the meeting in an address of welcome in which he stated that this year, as in the case of several previous years, he wished to stress the importance of open and frank discussion of the problems confronting the industry. He again asked the co-operation of all present and admonished the membership that only through giving freely the knowledge of their experiences could permanent benefit be derived from their attendance at the convention. Such exchange of ideas has contributed much to the remarkable progress of the industry and brought it to its present strong position.

Dr. E. R. Lederer, Texas Pacific Coal & Oil Company, president of the association, reviewed the past year's activities and accomplishments and stressed the fact that only through co-operative effort of the association has it been possible to achieve the present general acceptance of natural gasoline and other products of the industry by the refineries and the public. Citing natural gasoline statistics indicative of the balance of stocks and gasoline production, consumption and price, Dr. Lederer presented a warning thought in that possible increases in production may come from such districts as Oklahoma City, the Panhandle and West Texas, and cause some concern later this year. He urged a continuance of present efforts to maintain production in line with consumer requirements, while at the same time continuing the expansion of number of products from natural gasoline and the development of markets for these products.

REPORT ON REGRADING

At the afternoon session, G. M. Davidson, Empire Oil & Refining Company, and chairman of the specifications committee of the association, read a report of the committee's work during the past year which pointed to a regrading of natural gasoline with new specifications. The committee has been endeavoring to perfect specifications which will accurately designate the blending value of such products to refiners. The committee is still to finish this work and must eliminate a few remaining factors meeting with objection from the committee membership. Mr. Davidson expressed the thanks of the committee for the co-operation which has been received from member companies, refiners and others, and asked for further constructive criticism and assistance.

At this session A. J. Schlosser, Barnsdall Oil Company, presented two papers dealing with a comparison of California and Mid-Continent problems and methods. This discussion of methods in California was prepared by O. Weaver and that of Mid-Continent methods by J. E. Dale, both of Barnsdall Oil Company. Complete summary of cost data taken from a number of plants operating in both sections of the industry with an indicated difference of nearly three cents per gallon resulted in much discussion of the differing conditions under which plants are operated in the two areas. With California plant operation costs indicated at 3½ cents per gallon and costs summarized and averaged from the operation of 46 plants in the Mid-Continent area approaching a figure of nearly six cents per gallon, it be-

came necessary for the California delegation at the convention to outline the major differences in field and plant operation conditions on the West Coast. It was developed that larger volumes of gas, less extensive gas gathering systems, well pressure operations, very high throughput with attendant lower overhead cost per gallon, concentration of field activities, and the like, contributed to the much lower cost in California.

Proceedings of Natural Gasoline Association

REFINER'S DAY

Specifications and requirements of refiners was again brought into prominence on the second day of the meeting, which was designated as Refiner's Day. Through the frank discussion of mutual problems in this manner much data of value was presented and a spirit of friendly co-operation was fostered which assisted in furthering the work of the association in its efforts to develop specifications for new grades of naturals which may be interpreted in terms of actual value to the consumer of these products. The paper presented by M. H. Nolan, "Natural Gasoline Specifications from the Refiner's Viewpoint," and S. S. Smith's discussion of "Choice of Naturals for Blending," and E. W. Zublin's able presentation dealing with the blending value of natural gasoline, all of which were of real value and brought into discussion information directly applicable to the blending and usage of naturals, were discussed by R. B. High, who added to the work by designating the specific needs of the refining industry. It was agreed that the refiner is particularly interested in the composition of the natural gasoline he is purchasing, and some means should be developed of assuring him of the approximate composition before the arrival of the shipment. Those characteristics deemed most important in specifications and products were intermediate boiling points, volatility as expressed by intermediate boiling points or other empirical means, highest useful compression or anti-knock value, vapor pressure, and A. P. I. gravity to some extent. Mr. Nolen stated that refiners recognize the importance of volatility and anti-knock properties and how to interpret curve characteristics, and that they endorsed specifications indicative of the constituents of naturals and the effective volatility of these products. Through a series of charts illustrating the development of data contributing to the perfection of specifications, S. S. Smith presented an interesting and instructive paper which discussion was based on actual composition percentages of the hydrocarbon series concerned. Mr. Smith's work is presented elsewhere in this magazine. E. W. Zublin, presented charts to be used for blending to 10 per cent points, 50 per cent points, vapor pressures, and vapor lock conditions, and explained their uses and applications. While this work was intended to be of assistance to refiners and blenders who are only equipped with A. S. T. M. distillation apparatus and Reid vapor pressure test equipment, according to Mr. Zublin, it is, however, a convenient and fairly accurate working tool which should be of real value to all of the industry.

TREND TOWARD SIMPLE SPECIFICATIONS

The sense of the meeting may be summed up in that natural gasolines of low vapor pressure and high volatility are required by the refining industry and any specifications developed by the association must be indicative of these qualities or characteristics whether or not such specifications choose any one of a number of means of indicating these properties. It was evident, however, that any trend toward simplicity of specifications was more certain to meet with early endorsement by the industries concerned.

Following sessions were given over to the study of various subjects. W. K. Warren of Warren Petroleum Company interestingly presented a discussion of the sales problems of the indutry. Emby Kaye, Skelly Oil Company, in his paper "Outage" outlined the sources of losses in storage and shipping facilities and recommended methods of eliminating such losses. Dr. George Granger Brown in his highly instructive lecture showed the significance of volatility characteristics in motor fuels based on the associations four-year research program. Copies of Dr. Brown's book were available at the meeting rooms and are now available from association headquarters, Tulsa building, Tulsa, at a cost of $1.00. His lecture was based on the curves, charts, diagrams and other data presented in the book.

R. C. Alden, Phillips Petroleum Company, in his paper "Aviation Fuel" pointed to the growing importance of this type of product and discussed the characteristics of various fuels tested as a result of a survey conducted by his company. This paper was followed by a discussion presented by E. C. LeFevre, Empire Oil & Refining Company.

A paper by A. Kremser, Standard Gasoline Company, previously presented at a meeting of the California Natural Gasoline Association, "Theory of Absorption" was read and discussed; and the importance of theoretical analysis as the key to absorption plant design was stressed. This work was essentially a mathematical analysis of the absorption process which permits an evaluation of all important variables entering into the problem. In conclusion Mr. Kremser states "The relations presented are based purely on mathematical analysis without reference to empirical data. Their value has been demonstrated, however, by their successful application to practice covering a period of three years, and a wide variation of operating conditions encountered in over 40 gasoline plants. They have been a valuable aid in the design of plants, control of operations and evaluation of test data."

Lederer Again Heads Natural Gasoline Association

DR. E. R. LEDERER was re-elected president of the Natural Gasoline Association of America. He is vice president of the Texas Pacific Coal & Oil Company, Fort Worth, in charge of manufacturing. He has served one term as president and previously was a vice president of the organization.

Vice presidents of the organization also were re-elected: R. E. Beckley, Standard Gasoline Company, San Francisco; Emby Kaye, superintendent of the natural gasoline department of Skelly Oil Company, Tulsa; A. J. Schlosser, superintendent of the natural gasoline department of Barnsdall Oil Corporation, Tulsa.

Directors are elected by companies, which in turn designate the individuals to serve. Twelve directors chosen this year will come from the following company members: Sinclair Oil & Gas Company, Eagle-Picher Lead Company, The Texas Company, Skelly Oil Company, Amerada Petroleum Corporation, Phillips Petroleum Company, The Wentz Oil Corporation, The Henderson Company, Louisiana Gas & Fuel Company, Warren Petroleum Company, Columbian Gasoline Corporation and Hanlon-Buchanan, Inc.

The high spot on the entertainment program for the ninth annual meeting of the Natural Gasoline Association of America was the stag smoker. This was but one of the events provided by the Natural Gasoline Supply Men's Association. This program was given the evening of May 20 in the crystal ball room of the Mayo Hotel, Tulsa, where meetings of the convention were held May 20, 21 and 22.

The smoker is nothing new in the way of entertainment for the Natural Gasoline Association, as it has been a part of each convention since the supply auxiliary was formed. This year, however, the smoker program was worked out of the history of natural gasoline. An animated film in comedy vein presented this in striking manner.

FILM PRESENTED

The film was the work of Frank Werner, assistant director of the safety division of the Mid-Continent Oil & Gas Association. Werner's work along this line is known in the oil fields through the film character, "Old Man Bonehead." Werner also had charge of the musical and other numbers of the smoker.

A Dutch lunch each noon and the annual dance the second evening were other parts of the entertainment provided by the organization of supply men.

Natural Gasoline Supply Men's Association held its annual meeting May 21, when three directors were elected: A. W. Burket, Jackson Engineering Company; J. H. Satterwhite, Westcott & Greis, Inc., and B. L. Potter, Mid-Continent manager for Cooper-Bessemer Company. These directors will not take office until January, 1931, but the election is held in May, since the organization functions solely as an auxiliary of the Natural Gasoline Association.

These three, with R. E. Howe, Atlas Supply Company; A. J. Kerr, Pittsburgh Equitable Meter Company; M. H. Kotzebue, Tulsa Boiler & Machinery Company; J. C. McMahon, Foxboro Company, and M. F. Waters, Hanlon-Waters, Inc., will comprise the board for 1931. The directors will elect officials at that time. Dr. E. R. Lederer, president of the Natural Gasoline Association of America, is a member of the board.

ROLL OF MEMBERS

Membership of the Natural Gasoline Supply Men's Association includes:

American Car & Foundry Company; Atlas Supply Company; Cooper-Bessemer Company; C. F. Braun Company; The Bristol Company; C. F. Camp Company; Chaplin Fulton Manufacturing Company; Clark Brothers Company; Continental Tank Car Company; G. M. Davis Regulator Company; Dearborn Chemical Company; S. R. Dresser Manufacturing Company; B. V. Emery Company, Fisher Governor Company; Fort Worth Laboratories Company; The Foxboro Company; General Refractories Company; Goulds Pumps, Inc.; Griscom-Russell Company; Hanlon-Waters, Inc.; Hope Engineering Company; Hurley Brothers; Ingersoll-Rand, Inc.; Jackson Enginering Company; Jenkins Brothers; Magneto Ignition Company; the Meriam Company; Metric Metal Works; the Moorlane Company; National Petroleum News, National Tank Company; National Tube Company; Naylor Pipe Company; North American Car Corporation; The Oil & Gas Journal; The Petroleum Engineer; Petroleum Engineering Inc.; THE REFINER AND NATURAL GASOLINE MANUFACTURER; Pittsburgh Equitable Meter Company; Refinery Supply Company; Robinson Orifice Fitting Company; M. B. Skinner Company; Southwestern Engineering Company; C. J. Tagliabue Manufacturing Company; Taylor Instrument Company; Tulsa Boiler & Machinery Company; Victaulic Company of America; Vinson-Canter Company; Welders Supply Company; Westcott & Greis, Inc.; Westcott Valve Company; Whealton & Townsend, Inc.; Woobank Pump & Machinery Company; Worthington Machinery Corporation, and John Zink Burner Company.

Choice of Naturals for Blending

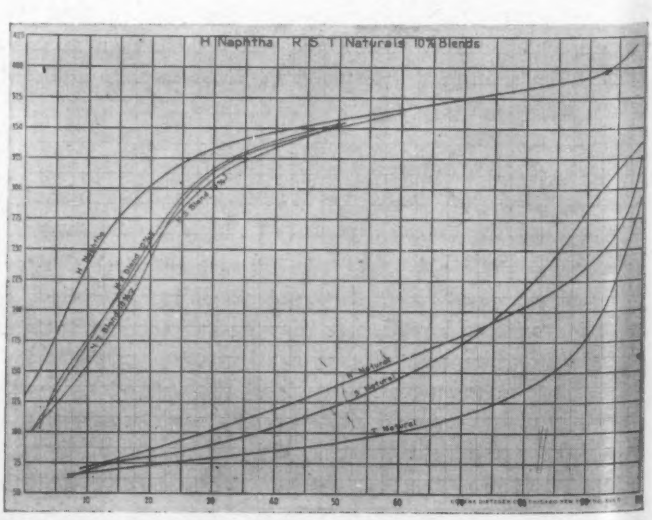
By S. S. SMITH
Shell Petroleum Corporation

REFINERS have lately come more and more to realize the importance of natural gasoline. The motoring public, educated by sales propaganda, asks for high test of volatile gasoline. Research provides large amounts of data proving the importance of proper volatility. Recent work very definitely correlates the A.S.T.M. distillation with certain phases of motor performance. We now know that ease of starting and the 10 per cent point of the A.S.T.M. are closely related. We know that acceleration depends on effective volatility which can be approximately predicted from the intermediate distillation points between 35 and 60 per cent. Dr. G. G. Brown will tell us in his paper that the best index of the vaporlock characteristics of a motor fuel is its vapor pressure. Throughout the last year, the Natural Gasoline Association has been engaged in research leading to new specifications. At the time of writing this paper the committee in charge of this work is not yet ready to report its new specifications. This committee has, however, assembled a vast amount of data which has been made available to those of us on this program. Since it is the purpose of this paper to describe blending values of natural gasoline the first step must be to define the natural gasoline.

Proceedings of Natural Gasoline Association

At the last Natural Gasoline Association convention, Oberfell and Alden of Phillips Petroleum Company, passed out an article describing the relationship existing between the 100° evaporated point and the 140° evaporated point of natural gasoline. After working with this original data for several months, it was evident that, while the central portion of the curves worked out fairly accurately, the extremities for low butane and pentane composition and high butane and pentane composition were incorrect. This original data, as I understand it, was compiled from the results of a great number of analyses of natural gasoline made in Phillips Petroleum Company's laboratory. In order to check this data we made a number of cuts of natural gasoline which corresponded with the natural proportions of normal hydro-carbons and their isomers as found in the average gasoline. Then using pentane-free bases from several widely separated plants, a number of synthetic blends were made, using pentane, butane and propane as the variables. From the A.S.T.M. distillation of these synthetic samples we then constructed Chart No. 1 which is attached. We have worked with this chart for six or eight months in our organization and have found, in actual practice, that analyses can be checked on individual components within two per cent with extreme regularity.

With this chart then we can evaluate the percentage composition of butane and lighter from the 100° evaporated point and the composition of pentane from the 140° evaporated point. No corrections for slope of the distillation curve are used with this chart, direct readings being made from the intersection of the 100° and 140° points which correspond to percentage butane and lighter and percentage pentane in the sample. Chart No. 1 by itself gives us no index of the differentiation between propane and butane in natural gasoline. The mathematical relationship between the vapor pressure of propane and butane is quite evident. By calculation we find that substitution of one per cent of propane for one per cent of butane in the natural gasoline gives us an increase in vapor pressure on 1 8/10 pounds Reid. For purposes of ease of calculation, we use two pounds as the factor indicating composition (not substitution) of propane in any natural gasoline. Now it will be seen that having determined the per-



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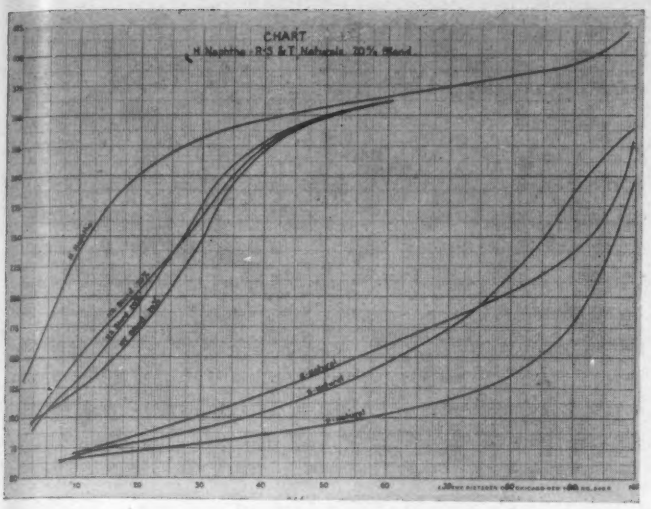

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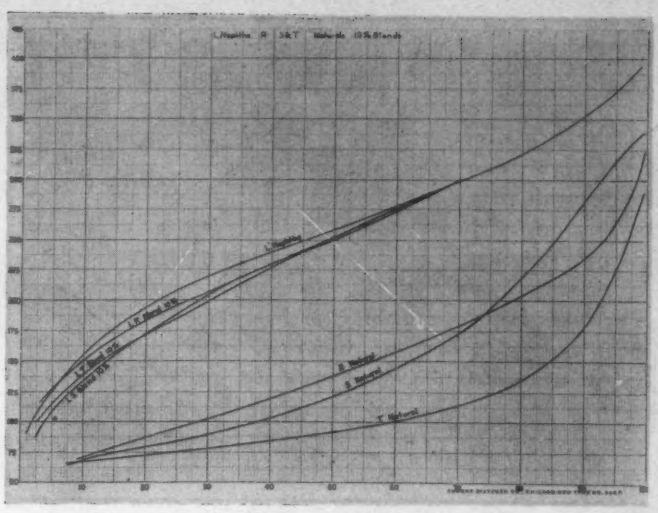

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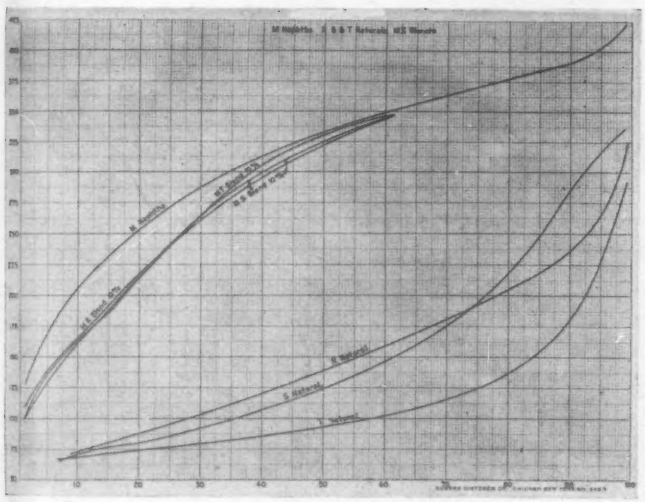

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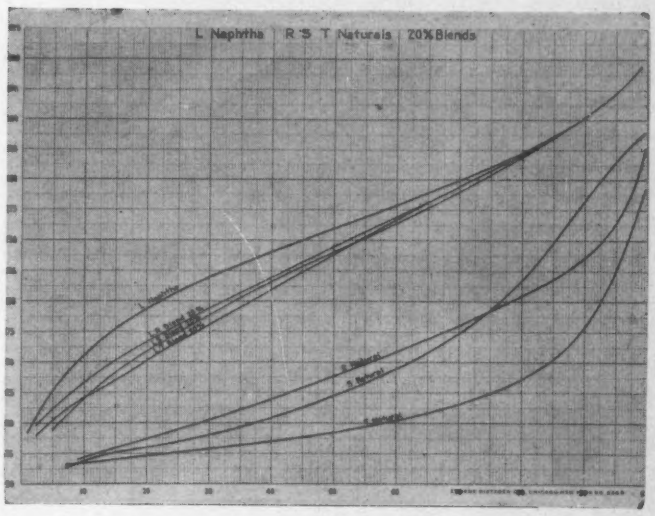

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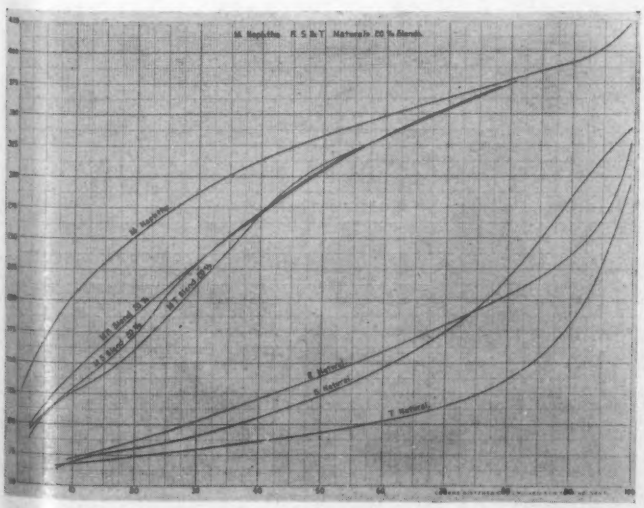

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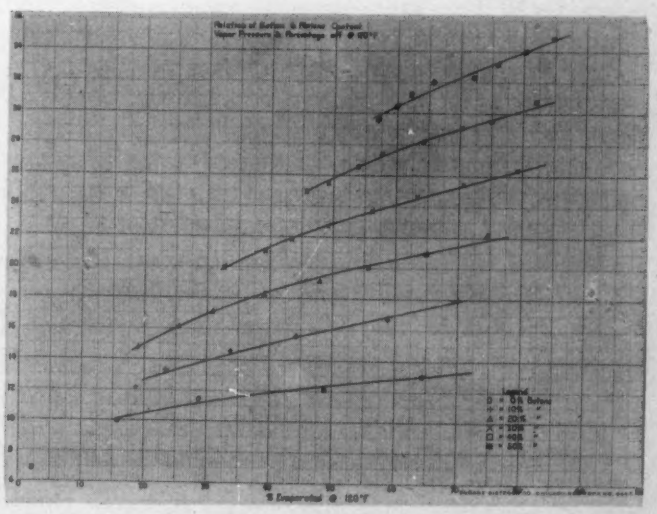

No. 14

centage pentane and the percentage butane and lighter from Chart No. 1 we can by reference to Chart No. 2, compare these known quantities and the observed vapor pressure of the sample with the vapor pressure of a propane-free gasoline of same butane-pentane composition.

Proceedings of Natural Gasoline Association

TO CALCULATE PER CENT PROPANE

The difference between the observed vapor pressure and Chart 2's vapor pressure in pounds Reid, divided by two, is then the per cent propane in sample. We have now determined close relationship between the distillation characteristics and the Reid vapor pressure which gives us an accurate analysis of the natural gasoline which we are going to use for blending. In view of the fact there are no determined specifications for the new grades, as yet, in this paper, consideration must be given to certain gasolines which can be assumed to be representative of the grades of gasoline now manufactured. It is fair to assume that, regardless of what type of specification is adopted, such specification will not materially change the types of gasoline which are now being manufactured by the various companies, using modern plants.

The Natural Gasoline Association's recent questionnaire to all natural gasoline manufacturers has given us a vast array of figures covering the distillation ranges and the vapor pressures on gasolines as currently made. For a number of months, in our own organization, we have used the Reid vapor pressures and the 100° distillation point as indices of the degree of stabilization or rectification obtained from field rectifying units. Chart No. 3A plotting per cents off at 100° against Reid vapor pressure shows four lines representing zero, one, two and three per cent propane. The base line for zero per cent propane passes roughly through the 28 per cent pentane point at 10 per cent of butane composition and through the 26 per cent pentane point at 40 per cent butane composition. A line drawn through 11½ pound Reid as base point with the same slope, represents ¼ per cent propane, and/or 24 per cent pentane at 20 per cent butane composition point, and 23 per cent pentane at 40 per cent butane. This line we have used as indicating the vapor pressure of average commercially propane free gasoline and have instructed plant superintendents to keep their rectifier operations in line with practice which would produce gasoline which, at any per cent off at 100, would not exceed this base vapor pressure line. If we be permitted to assume, and the assumption is borne out by N.G.A.A. figures covering 1,250,000 gallons of gasoline production daily, that a base line of 10 pounds plus ½ per cent off the 100 is representative of the average pentane content well rectified propane-free gasoline, then a study of blends as made with gasoline following along this line should be instructive.

As most of you know, nearly any natural gasoline if rectified, becomes a "AA" gasoline unless the gravity is too high. Excessive gravity, of course, is caused by high butane pentane composition. Study of the N. G. A. A.'s questionnaire shows that practically all "AA" gasolines fall along our 10 plus one-third the per cent off at 100 vapor pressure line between 40 and 55 per cent and if they are within the gravity limit group themselves pretty close to 50 per cent at 100. Checks of gasoline which are well represented by our Seminole production and some of the Texas' production fall between 50 and 65 per cent at 100 and group themselves around 60. These gasolines are outlaw AAs because of gravity. Some of the older plants, compression plants and the like, or plants which have low oil circulation rates, give us low pentane-butane gasolines which fall between 25 and 40 per cent at 100 with vapor pressures corresponding and falling along our 10 plus 1/3 line if stabilized. These three groups seem then to indicate a logical division of natural gasolines and for the moment at least let us consider blends of these types of gasoline and the effect of such blends on the finished 10 per cent point, vapor pressures, and the intermediate points. In the first place, it must be understood that gasolines which fall along the 10 plus 1/3 the percentage off at 100 vapor pressure line must, of necessity, be well rectified natural gasoline. We may consider in general then that we are dealing with propane free gasolines when they fall on our plus 1/3 line unless the pentane composition or ratio is abnormally low.

For the purpose of constructing blends of natural gasoline with naphtha we have chosen three naphthas which probably are comparable to average blending stock as used in refineries. The constants and distillations on these naphthas are as follows:

	"H" Naphtha	"M" Naphtha	"L" Naphtha
1	132	128	106
5	190	180	142
10	244	208	166
20	306	254	201
30	334	290	226
40	348	316	246
50	360	336	266
60	368	352	284
70	376	364	304
80	382	382	328
90	394	392	360
95	404	405	380
E.P.	424	420	398
Rec.	98	98	97
Res.	1.0	.8	1.0
V.P.	3	—	6.2
Reid	51.0	4.4	59.6
Grav.	—	53.2	—

Refiners like this CHAPMAN VALVE *because of its* low cost per year

Measuring its cost in terms of service, a Chapman Refinery Valve becomes one of the most inexpensive pieces of equipment in the plant. And measuring its service in terms of performance, it becomes one of the most satisfactory.

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You will note from the distillation curve that L. Naphtha is an average type of blending stock for gasoline such as might frequently be found for use in blending with small percentages of natural for improved motor starting and acceleration. Chart No. 4 shows the distillation curve for our L naphtha and shows two naturals, A and B, both of which have 50 per cent pentane base, the A natural having 36 per cent butane and 4 per cent propane. The vapor pressure of the A natural is 29½ pounds and the B natural 34.6 pounds. Curves for the resulting blends are plotted and their vapor pressures are listed. You will notice that 90 per cent of the L naphtha blended with 10 per cent of A natural gives a vapor pressure of 9.47 pounds while 10 per cent of B natural in the same L naphtha gives us a vapor pressure of 10.2 pounds, an increase of nearly a pound vapor pressure between the two grades of natural. Please note that these two naturals have approximately the same percentage off at 100, the A natural having 575 per cent at 100 and the B natural 57.1 per cent off at 100. This shows the effect of substitution of percentage propane for percentage butane in a natural gasoline and shows quite conclusively, particularly on the higher percentage blends, the bad effect of blending with high vapor pressure naturals which have approximately the same effect on the 10 per cent point while radically differing in their effects on the vapor pressures.

The curves as plotted on Chart No. 4 are not sufficiently accurate to bring out the differences at the 10 per cent point and that phase of the discussion will be covered later. The point to note in these particular blends is the effect on the vapor pressures of comparatively small percentages of propane, such as are actually found in unstabilized naturals. You will note that the A Natural is a typical natural having 91 recovery but 90 gravity, slightly above the limit for standard "AA" gasoline. The B natural crowds the limit of grade "C" with 77 recovery and 90.8 gravity. However, the only actual difference between the two gasolines is the substitution of four per cent propane for four per cent of butane to make the B natural from the A natural. It will be noted that the A natural falls exactly on our 10 plus one-third the per cent at 100 while the B natural is five pounds above this vapor pressure line. Now using the same L naphtha but another natural having 39 per cent at 100 and a vapor pressure of 32.2 pounds, we have plotted the five, 10 and 15 per cent blends on Chart No. 5.

RESULTS OF BLENDING

It is immediately apparent that using such a natural also, falls exactly on our 10 plus one-third line. to approximately a 15 per cent blend while obtaining the 10 per cent effect which we desire. This J natural also, falls exactly on our 10 plus one-third line. You will note that this L naphtha is perhaps too light to consider a normal blending stock, since it requires little natural to give it satisfactory starting and motor performance. Dr. Brown's data will probably show that the 15 per cent blend of J. natural with this L naphtha, due to its vapor pressure will give considerable trouble due to vapor lock at any atmospheric temperature above zero. In general, this finished blend at 15 per cent will be considered too light a fuel for anything except rather extreme cold weather conditions in northern countries. A five per cent blend would probably give excellent performance in a motor in anything up to exceptionally hot weather conditions.

Now take the case of another naphtha having much higher boiling range. Quite obviously in using a heavy naphtha we can take greater liberty with our use of naturals in the blend. We can use larger percentages of natural and we can also use naturals of more widely differing characteristics. For the purpose of showing some of these relationships we have constructed Chart No. 5A which shows the distillation range of our H naphtha and the distillation ranges of six blends made using two naturals, F and G having the same percentage off at 100. The F natural with 45 per cent off at 100, 75 per cent off at 140, Reid vapor pressure of 20.6 pounds, has a composition of 20 per cent butane and 60 per cent pentane in the butane-free base. The G natural, with 45 per cent at 100, 59 per cent at 140, 26.6 pounds Reid vapor pressure, has 40 per cent butane and 20 per cent pentane in the butane-free base. Six blends are plotted showing the effect of 10, 20, and 30 per cent of the F and G natural on the original naphtha.

The interesting thing about these blends is the fact that the low pentane content natural requires 30 per cent blend to reach the 10 per cent point which the high pentane content natural reaches with a 20 per cent blend and the vapor pressure of the two blends differ by only .4 pound. In other words, against a heavy naphtha a high pentane base stock will give the same effect at the 10 per cent point used in much smaller quantities while keeping the vapor pressures much lower. If the blending considerations require that we influence the 35 per cent point by lowering its temperature, then quite obviously the high pentane natural which permits much larger percentage blending without unfavorably affecting the vapor pressure, is the gasoline which we should use. It is particularly significant that the 30 per cent blend of low pentane natural has 11.3 pounds vapor pressure while the 20 per cent blend of high pentane natural has a vapor pressure of 9.5 pounds while the 10 per cent point remains practically the same and, while there is almost 75 degrees difference between the 35

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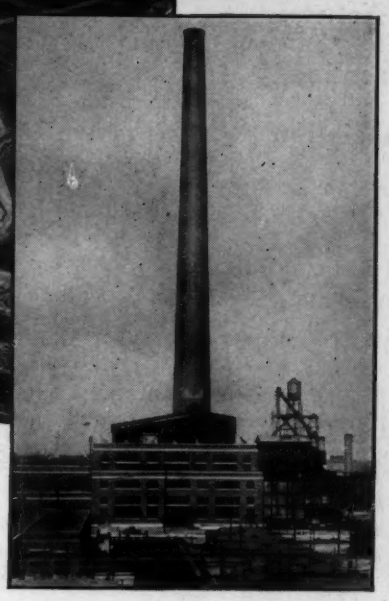

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per cent point in favor of the high pentane base natural.

We have shown the effect of high propane content in the finished blend of our L naphtha. We have also shown the effect of high and low pentane content in a blend with our H heavy naphtha. Chart 6 shows the distillation curves of H naphtha, the distillation curves of our same A and B naturals and six blends. The A natural has 40 per cent butane, 50 per cent pentane base and V.P. of 2 plus 2 pounds Reid. The B natural has four per cent propane, 36 per cent butane and the same 50 per cent pentane base, with 34.6 pounds Reid V.P. The 10 and 20 per cent blends of these two naturals with H naphtha show within close units the same 10 per cent points, 6.1 pounds versus 7.4 pounds vapor pressure for the 10 per cent blends and 8.8 pounds and 11.7 pounds vapor pressure for the 20 per cent blends. It will be seen that against a heavy naphtha blending stock, it is possible to reach practical 10 per cent points using a high propane content gasoline particularly for winter fuels where high vapor pressures are not objectionable.

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PRACTICAL APPLICATION

Now for a practical application against a fixed type of naphtha using two different types of casinghead to fit summer and winter driving conditions. For this purpose let us use the M naphtha which we described early in this paper. This naphtha, you will recall has an initial of 128, an uncorrected 10 per cent point at 208 and a vapor pressure of 4.4 pounds. The naturals to be considered are first the K natural having 40 per cent butane and 60 per cent pentane in the butane-free base. Its characteristics are 62 per cent off at 100, 82 per cent at 140, 29.6 pounds Reid V.P., and distillation loss of eight per cent. This, you will notice, is a high volatile natural, falling just about on our 10 plus one-third vapor pressure line and having average "AA" characteristics except for high gravity. Blending this gasoline with our naphtha to a 15 per cent blend gives us a corrected 10 per cent point of 120° and a Reid V.P. of 11.2 pounds. Our Q natural has 30 per cent butane and 50 per cent pentane in the butane-free base. Its characteristics are 47 per cent at 100, 73.5 per cent at 140 and 24.2 pounds Reid V. P. This gasoline, blended with our naphtha in a 10 per cent blend, gives us a corrected 10 per cent point of 146° and a vapor pressure of 7.2 pounds. These two finished blends might, I believe, be considered excellent summer and winter fuels. The blends considered so far, if accepted at their face value, show several things of interest.

First, high vapor pressure natural, whether due to reduced pentane content or increased propane content, will not permit sufficient percentage of blend to give us conditions we frequently desire on heavy naphtha without running into trouble due to vapor pressure with consequent vapor lock in the motor fuel performance. Second, high pentane-base stocks are useful in effecting the 35 per cent point and consequent motor performance, in acceleration and ease of warming up. Third, it is useful to use a high volatile natural gasoline for blending for winter fuel where rather high vapor pressure is not necessarily a detriment to the finished fuel. Fourth, in blending to summer fuel, care should be exercised that the natural is a low vapor pressure and not too excessive in its volatility as expressed by the 100° F. point. Admittedly, the few examples given do not prove the case. They are mentioned for the purpose of pointing out a few of the salient points by the use of exaggerated examples.

These exaggerated examples may be said to overemphasize the importance of pentane content in the finished blend. On the other hand they do show definite trends which are important to us, particularly, if we use natural in blending to close limits on our motor fuel. In other words, if our base stock, or naphthas, which we are going to blend, limit us to close control of the 10 per cent point and the vapor pressure, then the type of natural selected for such blending has an important bearing on whether or not the blending operations will be successful.

FROM ASSOCIATION PROGRAM

The Natural Gasoline Association research program laid out and carried through a series of blends of 15 per cent natural and 85 per cent fixed naphtha. The chairman of the technical committee, G. M. Davidson, has already reported the information derived from these blends.

In connection with some of the statements already made in this paper, it is interesting to note, trend curves taken from the data compiled by the Association. Chart No. 10, as made up by the technical committee, shows the definite 10 per cent evaporated temperature of the A. S. T. M. distillation and the vapor pressure in pounds Reid of finished blends of 15 per cent natural with a fixed naphtha base. My chart does not show the colors representing the different pentane bases but that has already been covered by Mr. Davidson.

From the data on Chart No. 10 , we have made up Chart No. 11 which shows quite clearly the effect of decreasing pentane content with corresponding increasing butane content in the natural from which the blends are made. You will notice that the 10 per cent point lowers uniformly with an increase in vapor pressure as we increase butane and decrease pentane up to the point where we have 30 per cent butane in the natural. From 30 per cent upward it will be noted that practically the only change made in the finished blend is to increase the vapor pressure. This point was covered previously in our low pen-

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tane content natural blend with our M naphtha, but the single instance cited of course does not prove the case.

The exhaustive work done by the technical committee of the Natural Gasoline Association, however, can be taken as conclusive and shows very distinctly the desirability of using high pentane base natural for summer blending requirements and the permissability of high butane stocks for winter blending. As a guide in blending, we have found in correlating the blended products with the components of the blend that within very close limits the percentage evaporated at any temperature can be calculated from the percentage evaporated in the two components.

For instance, a naphtha having 20 per cent evaporated at 200° blended with a natural which has 85 per cent evaporated at 200° permits us to calculate the per cent evaporated in the finished blend. Ten per cent of the natural will give us 8.5 per cent evaporate and 90 per cent of the naphtha will give us 18 per cent evaporated at 200° F. The two added give us 26.5 per cent evaporated at 200° F. In practice blends will be found to follow this rule with remarkable accuracy. In the same way, we can calculate in advance the vapor pressure of the finished blend by using the molecular percentage of the natural times its vapor pressure plus the molecular percentage of the naphtha, multiplied by its vapor pressure. Results of such calculations will be found to check actual practice closely within the error inherent in our Reid vapor pressure apparatus.

SUMMARY

We can now sum up the situation as follows: Given the Reid vapor pressure and the percentage off at 100 on a natural which is to be used for blending, we can check this specification and find out whether or not the vapor pressure is properly in line with the percentage off at 100. If we find it to be so, we know that we have a natural which does not contain appreciable amounts of propane nor appreciably reduced amounts of pentane. If this is the case, we are safe in assumnig that this natural can be used to blend to any type of specification we desire in a finished motor fuel, and the only criterion we need observe is that the per cent off at 100, or the volatility, is not excessive for the seasonal blending requirements. After receipt of the natural and proper checking of its vapor pressure, per cent off at 100, and per cent off at 140, we can determine with considerable accuracy the percentage of components although such determination is not necessary for intelligent blending. The only necessities are the vapor pressure and the distillation curve, both of which can be used against the vapor pressure and distillation curves of our original naphtha to calculate the characteristics of our finished motor fuel.

Blending Value of Natural Gasoline

By E. W. ZUBLIN
Texas Pacific Coal and Oil Company

REFINERS have come lately more and more to realize the importance of natural gasoline. The motoring public has been educated by sales propaganda to ask for high test or high volatility gasoline. Research has provided a large amount of data proving the importance of volatility. Recent work has very definitely correlated the A.S.T.M. distillation with certain phases of performance in the motor. Today we know that ease of starting and the 10 per cent point of the A.S.T.M. distillation are very closely related. Acceleration depends on effective volatility which in turn can be predicted from the intermediate, the 35 to 60 per cent points of the distillation. Volatility and knock rating show certain relations, and the troublesome vapor lock has now been recognized to be the result of excessive volatility.

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Few crudes produce straight run gasolines sufficiently volatile to conform with the prevailing standards. Most refiners have to add natural gasoline to their product even when the requirements are not better than U. S. motor specifications.

Blending is an art as old as the natural gasoline industry. In spite of the many years, during which blending has been practiced, the quantities to be added are usually determined by guessing, a method based on the experience of the operator rather than on figures and charts. This is the more surprising as it is relatively easy to construct fairly accurate blending charts for various purposes. Perhaps the reason for this lack lies in the difficulty to find blending curves that apply to any grade of natural gasoline. This difficulty can be overcome by expressing all blending data in per cent of the difference between respective points.

It is the purpose of this paper to present a blending chart for practical use. The need for such a chart has long been known and it is hoped that this contribution helps to reduce the time and labor put up to blend gasoline to specifications and to permit process men to make more accurate calculations as to disposal of tanks and tank cars. This latter point is especially important in refineries where several grades of gasoline are manufactured, and where the tankage is limited. Very often a tank must be held because the laboratory will not give its approval, till more natural has been added. Many valuable hours may thus be lost. Such trouble can be avoided by consulting blending charts such as the one proposed.

CHARTS EXPRESS EXPERIENCE

In this paper no attempts have been made to give any theoretical explanation for the curves developed nor have calculations of any kind been made. The charts are merely the outcome of a systematic collection of blending data over a long period of time. As previously mentioned, they are based on the principle of expressing the properties of the blends in per cent of the difference between equivalent properties of the blending stocks. This per cent difference is plotted against the per cent of natural gasoline. To make this point clear consider for instance the 10 per cent points of two blending stocks: That of a naphtha be 200° F. and that of a natural 70°F. The difference is 130°F. We find that upon addition of 20 per cent of this natural to the naphtha, the 10 per cent point of the latter drops to 144°F, which is 56°F. lower than the original. 56° constitute 43 per cent of the total difference 130°. This gives us one point for the curve at 20 per cent natural gasoline. On blending any other naphtha with 20 per cent of any other casinghead gasoline we find that the 10 per cent point of the naphtha again drops 43 per cent of the total difference within close limits.

The accuracy of the curves thus constructed is fairly good. The largest deviation ever found and checked amounted to five per cent of the total difference or five per cent of the per cent natural gasoline added. Larger deviation always could be traced to poor mixing or errors in the A. S. T. M. distillation.

The properties covered by the present work are: The 10 per cent point, 50 per cent point and distillation loss of the A. S. T. M. distillation, the vapor pressure (and vapor lock) and the knock rating.

When working with the A. S. T. M. distillation or points of it one always has to keep in mind that there are two series to be considered; the one uncorrected, as it is taken down during the test, and the other one corrected for distillation loss. In my experience

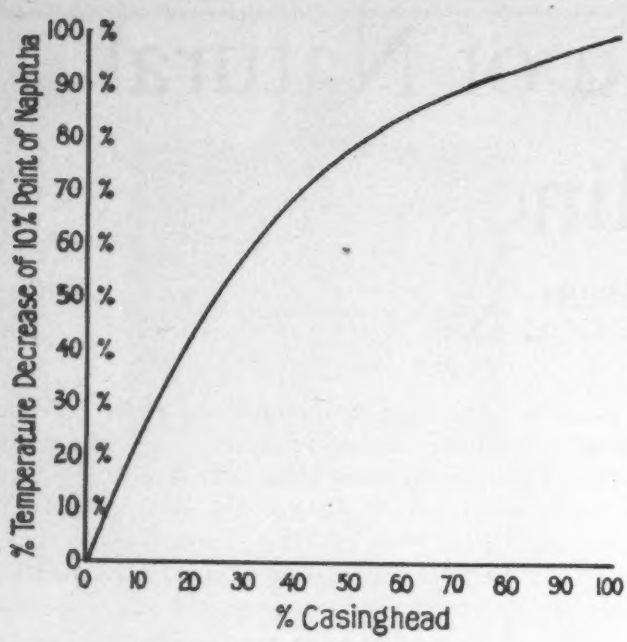


Figure 1

Ten per cent point and natural gasoline.

in most routine laboratories little attention is paid to correcting any points, though the latest government specifications require it for the 10 per cent point. Concerning our blending charts it was found that in order to make them applicable to all grades of naphthas or natural gasolines, the uncorrected 10 per cent and the corrected 50 per cent or higher points must be used. Just why this is the case is a matter of speculation. Possibly it has to do with the distribution of the distillation loss over the lower end of the distillation curve and also with the predominant influence of the lighter stock on the lower points only. For practical reasons it is fortunate that the 10 per cent point need not be corrected to figure the resultant blend. It would be difficult and highly inaccurate to estimate the correction for the 10 per cent point of a natural gasoline with 10 per cent or more distillation loss. According to the Bureau of Standards a deduction of 5.4°F. shall be made for every cc distillation loss below five cc. This represents a fairly good average correction and avoids the trouble of having to draw the distillation curve. However where the distillation loss exceeds five per cent the possible error of the average correction factor becomes so great that the distillation curve must be used; and where the loss is greater than eight per cent, the 10 per cent can no longer be corrected accurately even with the aid of the curve, because in such a case the distillation loss is not confined to the first 10 per cent coming over, but is distributed over a much wider range.

For the 50 per cent conditions are quite different. It is necessary to use the corrected values in order to obtain a smooth curve applicable to all grades of blending stocks. The difficulties encountered for correcting this point are not as great as for the 10 per cent point. For most purposes it is sufficient to deduct 2.4°F. for every cc distillation loss, even where this loss exceeds five cc. If greater accuracy is desired the only way is to draw the distillation curve and to translate it to the right for the amount of the loss.

Uncorrected points above 50 per cent are usually little affected by the addition of small percentages (less than 30 per cent) of natural gasoline. Addition of 10 per cent or less may even raise them slightly because the influence of the increase in distillation loss exceeds the actual lowering. The corrected points of natural blends (including the 20 per cent point) of course are always lower than those of the original naphtha. However, there is no simple way such as the deduction of a constant value for every cc distillation loss to approximately correct the 90 per cent point. The distillation curve must be drawn and this is rather impractical. For these two reasons the 90 per cent point has not been included in the present series.

Other points of the A. S. T. M. distillation such as the initial boiling point, the 20 per cent and the final boiling point were omitted because according to work published by G. G. Brown of the University of Michigan and O. C. Bridgeman, Bureau of Standards, they have little or no relation to any of the actual performance characteristics.

VAPOR LOCK

Much has been said lately about vapor lock. Dr. G. G. Brown showed and the writer has done work supporting his opinion, that the best single test for vapor lock is the vapor pressure as measured by any of the methods giving reproducible results such as the Reid bomb method. In most gasolines the 10 per cent point and the vapor pressure show a close relation, but exceptions have been found. Brown's

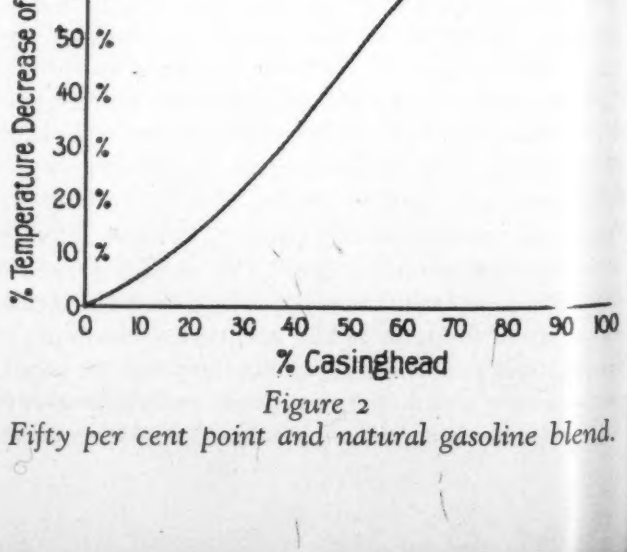


Figure 2

Fifty per cent point and natural gasoline blend.

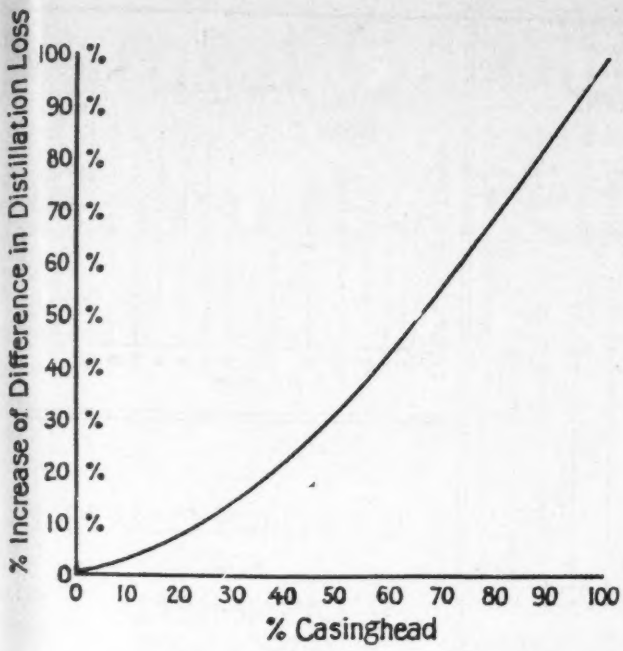


Figure 3
Distillation loss and natural gasoline blend.

empirical formula correlating the 10 per cent point and vapor lock is subject to similar exceptions. Gasoline manufacturers who desire to estimate the vapor lock tendency of their product from the vapor pressure may consult the section on vapor pressure of the present chart. The scale for vapor lock temperatures is based on the assumption that vapor lock occurs or may occur at the temperature at which the Reid vapor pressure equals atmospheric pressure. (14.7 pounds per square inch).

Brown observed that the temperature of gasoline in the average carburetor readily climbs as high as 100°F., ½ atmospheric temperature °F. Therefore, the vapor lock temperature of gasolines should not be lower than the temperature calculated by the above formula, taking for the atmospheric temperature a high seasonal average of the district in which the product is sold.

Noteworthy is the change of knock rating caused by the addition of natural gasoline. One might expect that the grade or the source of the natural gasoline would influence its knock rating. It was found, however, that all naturals, with exception of some of the grades A have the same knock rating within close limits, as determined by the bouncing pin method and expressed in the Ethyl scale. The theoretical knock rating of natural gasoline is about zero, i. e., equal to the present Ethyl standard. Well stabilized natural gasolines, being superior from the point of view of volatility, very often have a slightly poorer knock rating. In preparing the curve showing the knock rating versus per cent casinghead, blends were made containing up to 70 per cent casinghead. Altogether 88 blended samples (not including Grade A) were tested and the following deviations from the curve were noted:

Number of Samples	Deviations
32	0 c.c. lead tetra ethyl
48	.1 c.c. lead tetra ethyl
4	.2 c.c. lead tetra ethyl
—	
88	

Naturals from Pennsylvania, Mid-Continent, California, West Texas, Gulf Coast and Venezuela were included in these tests.

EXPRESSED IN STRAIGHT LINES

The curves constructed from laboratory data (Figs. 1 to 4) showing the change of properties with the addition of natural gasoline are the basis for the blending chart. In the latter the properties of the two blending stocks are evenly distributed on vertical scales, while the horizontal scales for the per cent natural gasoline have been derived by transcribing on the abszissa the vertical distances of the curves from the abszissa for the various percentages of natural. By using such scales the curves for all properties become straight 45° lines. Thus the blending charts have been brought to a form in which all relations are expressed by straight lines, and problems can be solved by the mere application of a straight edge.

To explain the use of the chart the following example shall be demonstrated:

A certain gasoline stock on hand having the following properties:

10 per cent at 200° F.
50 per cent at 291°F. uncorrected, 290°F. corrected.
Distillation loss—½ per cent.
Reid vapor pressure at 100°F. — 4.2 pounds.
Knock rating—2.4 cc lead tetraethyl poorer than Ethyl standard, shall be blended with a casinghead of the properties:

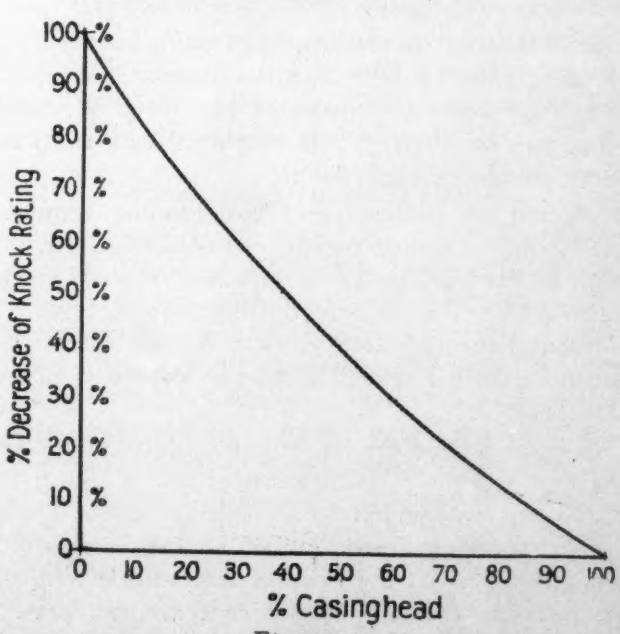
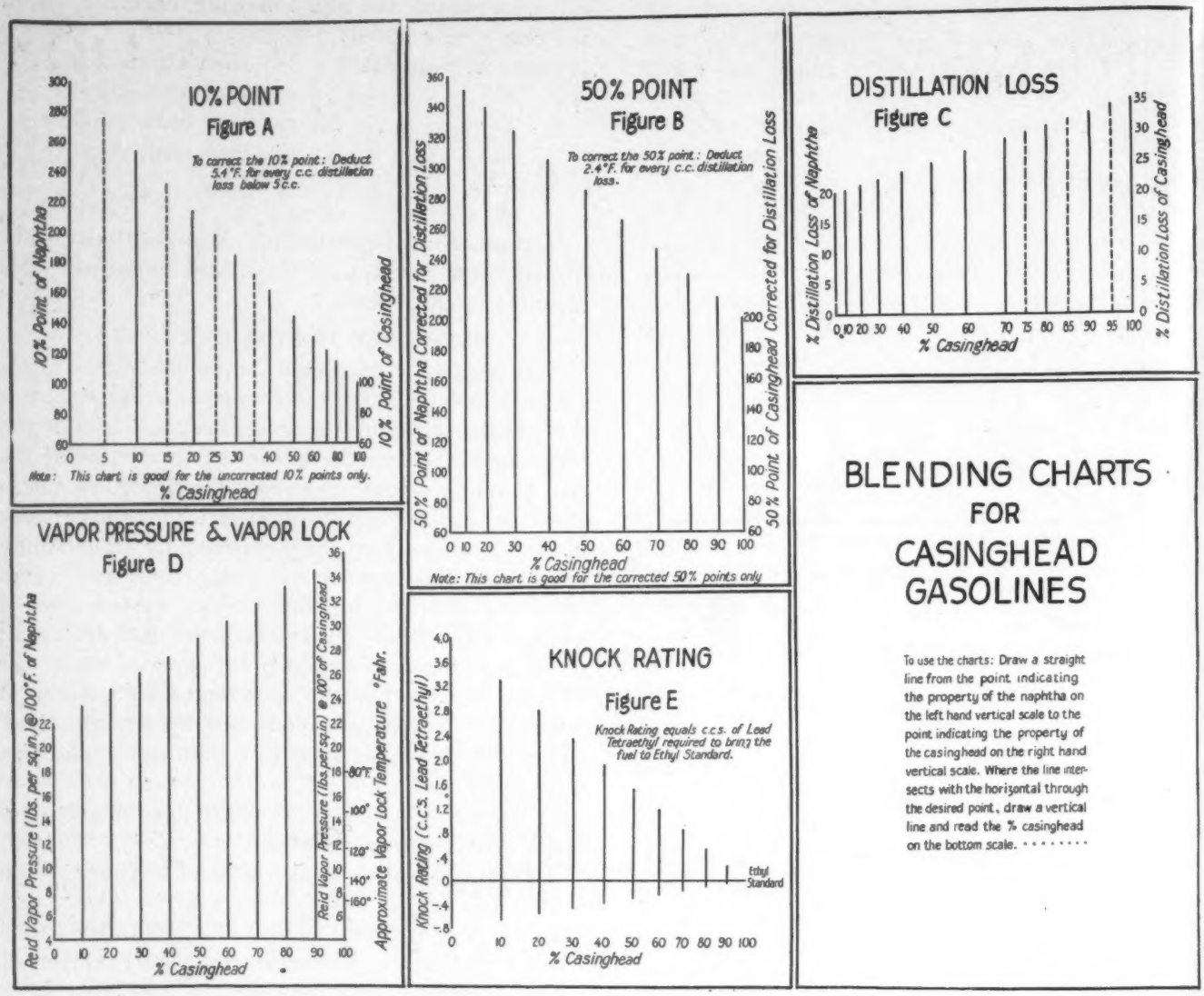


Figure 4
Knock rating and natural gasoline.


10% POINT
Figure A
To correct the 10% point: Deduct 5.4°F. for every c.c. distillation loss below 5 c.c.
10% Point of Naphtha
10% Point of Casinghead
Note: This chart is good for the uncorrected 10% points only.
% Casinghead
50% POINT
Figure B
To correct the 50% point: Deduct 2.4°F. for every c.c. distillation loss.
50% Point of Naphtha Corrected for Distillation Loss
50% Point of Casinghead Corrected for Distillation Loss
% Casinghead
Note: This chart is good for the corrected 50% points only
DISTILLATION LOSS
Figure C
% Distillation Loss of Naphtha
% Distillation Loss of Casinghead
% Casinghead
VAPOR PRESSURE & VAPOR LOCK
Figure D
Reid Vapor Pressure (lbs. per sq.in.) @ 100°F. of Naphtha
Reid Vapor Pressure (lbs. per sq.in) @ 100° of Casinghead
Approximate Vapor Lock Temperature °Fahr.
% Casinghead
KNOCK RATING
Figure E
Knock Rating equals c.c.s. of Lead Tetraethyl required to bring the fuel to Ethyl Standard.
Knock Rating (c.c.s. Lead Tetraethyl)
Ethyl Standard
% Casinghead
BLENDING CHARTS
FOR
CASINGHEAD
GASOLINES
To use the charts: Draw a straight line from the point indicating the property of the naphtha on the left hand vertical scale to the point indicating the property of the casinghead on the right hand vertical scale. Where the line intersects with the horizontal through the desired point, draw a vertical line and read the % casinghead on the bottom scale.

10 per cent at 70°F.

50 per cent at 100°F. uncorrected, 95°F. corrected.

Distillation loss 14 per cent.

Reid vapor pressure at 100°F.—32 pounds.

It is desired to produce a gasoline having a 10 per cent point of 150° F. uncorrected. How much natural gasoline is required? How will the other properties be affected? Is the blend safe from the point of view of vapor lock?

To find the percent of natural gasoline required, use figure A. Connect with a straight edge the 200° point on the left hand scale with the 70° point on the right hand scale. Where the line intersects with a horizontal through 150°, draw a vertical line to the natural gasoline scale. Read the per cent, in our case 17½.

In order to find the 50 per cent point of the blend we must use the corrected data given. Connect the 290° point on the left hand scale of figure B with the 95° point on the right hand scale by means of a straight edge. At the point of intersection with the vertical line through 18 per cent natural, draw a horizontal line. Read the corrected temperature, in our case 268°F.

In order to estimate the 50 per cent point as it would be read on the thermometer, the distillation loss must be determined in figure C—in a similar manner as described above. For every c.c. distillation loss below five c.c. 2.40°F. must be added. In our example we find 1.5 c.c. distillation loss and an uncorrected 50 per cent point of 272°F.

The Reid vapor pressure corresponding to 17½ per cent natural, as found on figure D, is 9.4 pounds at 100°F., and the vapor lock temperature is 138°F. This gasoline is safe as to vapor lock at atmospheric temperatures up to 76°F.

The knock rating of the blend as determined on figure F is 1.8, that is to say, 1.8 cc of lead tetraethyl are required to make its knock equal to that of Ethyl standard.

Other problems, such as the determination of the properties required of a natural gasoline to produce a blend of certain specifications, can be solved just as easily with the present charts.

If there should be a demand for specifications of other properties not covered by this paper, such as the proposed per cent over at 100°F for natural gasoline, additional charts can be constructed easily as long as the principles outlined here are followed.

Natural Gasoline Specifications From the Refiners' Viewpoint

By M. H. NOLAN
Producers and Refiners Corporation

Proceedings of Natural Gasoline Association

THE manufacturers committee of the Western Petroleum Refiners Association, in accepting an invitation to be present and participate in this convention by the presentation of papers, decided that it might be of interest to present the viewpoint of the refiners with regard to natural gasoline specifications, and particularly in view of the great amount of interest displayed in papers presented by members of the Natural Gasoline Association of America at a recent meeting of the refiners at Shreveport.

At the outset, in preparing material for such a paper it was the intention to elicit an opinion from each member of the refiners association by means of a questionnaire, but due to the time necessary to complete such a procedure, the idea had to be abandoned and a more expedient method resorted to—that of arranging interviews with several of the representative members of the association. The opinions obtained as a result of these interviews, were, as might be assumed, of a rather widely varying nature.

It is quite natural to suppose that the opinion of the individual refiner, would, to a certain extent, be governed by his own particular situation, and in this regard, we might class the individual refiner in three large classes, i.e., those refiners who are a part of the large integrated company, in close contact with the manufacture of natural gasoline—with facilities and material available by which he has equipped himself with a thorough knowledge of the subject and does not hesitate to express an opinion; the second class which may or may not be a part of the integrated company but who does not have direct contact with natural gasoline manufacture, and with rather limited facilities and depends to a great extent on the literature for his knowledge, and therefore hesitates to express an opinion, and as the third class, the smaller independent refiner, who has few of the advantages of the other two classes and whose knowledge is limited, and due to this fact, is quite reticent to express an opinion.

To better understand the refiner's viewpoint, let us look at the question from his angle and consider some of the factors that might enter in and influence his opinion as to what natural gasoline specifications should be from his particular point of view. First, and possibly most important, is his raw material or crude oil, as you are well aware that with a raw material as widely varying in composition as crude oil, the refiner, by direct distillation, may produce a product varying from a highly volatile gasoline to a heavy comparatively low volatile naphtha. That the equipment in which this product is distilled may vary from the so-called direct distillation to the highly fractionated product of the modern bubble tower. The refiner, to further increase his production of gasoline, employs one of the many types of cracking equipment. Here again enters a factor that varies his product, depending on whether the process used is of the comparatively low pressure, low temperature type or the high pressure, high temperature type or possibly the more recent vapor phase type.

This final and quite important factor that enters to vary his product and thereby his opinion is his stabilization and vapor recovery equipment. This equipment will vary his product, depending on whether it includes the stabilization of crude or pressure distillate or both —whether the vapors from such stabilizers, when mixed with ordinary refinery gases or vapors, are processed through an efficient recovery plant for the production of highly volatile gasoline, and whether this highly volatile gasoline is properly stabilized.

VIEWPOINT OF REFINERS

From the summation of opinion thus far, we have considered only those factors that would influence the refiner by reason of his own particular situation and which are only a small part of his problem.

Let us now consider the other factors that he must take into consideration and which exert a great deal of influence on his opinion of what natural gasoline should be and their equivalent specifications. The refiner has long been aware that the most important characteristic of his motor fuel is volatility and has more recently learned that the other important characteristic, second only to volatility, is its anti-knock properties. To determine the degree of volatility of his products, the refiner, of course, resorts to the distillation test. There

was a time when this test told little or nothing of actual volatility of his product, but partly through his own experience, partly through the efforts of his research laboratory and, to a large extent, to information derived from highly specialized investigators, he has learned, at least to a certain degree, to interpret the results of his distillation test in terms of motor performance. In this connection he has learned that instead of initial, the five, 10 or even the 15 per cent point represents ease in starting, that the 10 per cent point when correlated with the vapor pressure may indicate vapor locking tendencies—that the curve up to the 35 per cent point indicates satisfactory operation during the warming-up period without excessive use of the choke, that the 50, 60 or even 65 per cent points are indicative of the time of acceleration—that those points above 65 per cent are comparatively ineffective as far as volatility is concerned but may pass certain limits and become heavy enough to result in crank-case dilution or light enough to result in loss of power when the motor is thoroughly warmed up.

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Thus if the refiner is to produce a satisfactory motor fuel, he must consider all the points on the Engler Distillation curve from five per cent point to the 90 per cent point, many of which are closely defined and must be varied within certain limits, depending on the atmospheric temperature and the location in which the fuel is to be used. Here, also, we must consider recovery and gravity. Recovery at the present is a part of nearly every motor fuel specification and its importance is expressed in the U. S. motor specifications, in which it becomes the limiting factor of volatility as expressed by the 10 per cent point. The refiner is fully aware of the fact that gravity so far as volatility or motor performance is concerned means nothing, yet his products are still being sold on a gravity basis and are so quoted on the market. This is particularly true in certain localities where gravity is still accepted as a criterion of quality and demanded as such. As to the anti-knock characteristics of his motor fuel, the refiner realizes that this is, to a great extent, a function of the character of his raw material, of the type of cracking equipment employed and the method of the final refining of the product. Anti-knock is also in a lesser degree a function of the volatility of the product in so far as those components responsible for the volatility are anti-knock in character.

Now that we have considered all the points that the refiner must consider, is it any wonder that the refiner hesitates to express his opinion and that the opinions so expressed are of a widely varying nature.

As the refiners gasoline or base stock varies in volatility characteristics compared to the specifications set up as to what constitute a satisfactory motor fuel, so also do his requirements for natural gasoline, to a certain extent, vary. How, then, is the refiner to select the grade of gasoline best suited to his needs? Can he, under the existing specifications of gravity and recovery, intelligently make his selection, or are there certain other physical characteristics exhibited by natural gasoline that will more definitely define its utility.

VOLATILITY GUIDES

From his experience the refiner knows that his natural gasoline blending up to the present has been more or less of a cut and try method, and when by this method he decides on a certain grade he finds that although successive purchases of this grade may meet the present requirements of gravity and recovery, that its volatility characteristics, as expressed by the Engler distillation, vary over a wide range. That this variance is reflected to a certain degree in the finished blend and at times constitutes the difference as to whether his motor fuel does or does not meet specifications.

By reason of these observations the refiner believes that as he must market his gasoline on volatility characteristics as expressed by the Engler distillation, that he should also purchase natural gasoline on this basis. He has been shown that volatility of natural gasoline is a function of the relative proportion of its components, i.e., the individual hydrocarbons present. That these hydrocarbons, for ease of consideration, have been grouped as butanes and lighter, pentanes, and hexane and heavier. That specification should show a close relationship to the relative volume of these groups —that the percentages evaporated on the Engler distillation at given temperatures may be interpreted as per cent of these groups. He has further been shown that vapor pressure is closely related to vapor locking tendencies—that vapor pressure is a direct function of butanes and lighter and that for a given propane content the vapor pressure is closely related to the content of butane and lighter and that vapor pressure will perform the function now accomplished by distillation loss.

I will say to you that the average refiner is adverse to giving up the gravity and recovery as specifications, if they could be included with points on the Engler curve, but in light of the information supplied him, I am sure the refiner would heartily endorse any set of specifications so based on the per cents evaporated on the Engler curve in direct per cent (corrected for loss) that would bear a close relationship to the group composition, and the vapor pressure performing the function of distillation loss.

That by the correct interpretation of such specifications he would be capable of determining the effective volatility of each grade and select that grade best suited to his needs. In so doing natural gasoline would be of greater utility to him and in consequence be used in greater proportion, resulting in a benefit to the natural gasoline manufacturers, the refiners and to a satisfied motoring public.

Discussion of Nolan Smith and Zublin Papers

By R. B. HIGH
Shell Petroleum Corporation

THE preceding papers have given us all a fair working knowledge of the methods that can be used in blending two component mixtures of naphthas and natural gasoline. Much interesting information has been brought out and I am sure we have all profited by the emperical and calculated data given.

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I will not attempt to comment upon the papers separately as I prefer to group the complete subject under a general discussion.

Summarizing the detailed specifications, we have seen that we are interested:

1. Intermediate boiling points.
2. Volatility as expressed by some intermediate boiling point or by other emperical means.
3. Highest useful compression or anti-knock value.
4. Vapor pressure of the finished blend.
5. A.P.I. gravity to some extent.
6. And lastly, but indirectly, the cost of natural gasoline.

Some literature has been published on the effect of lowering the end point. This is of minor importance and is practically negligible on the higher percentage blends, while for the usual blends generally handled in the refineries, it may be disregarded entirely.

It is not necessary to go into further detail in the effect of natural gasoline on the intermediate boiling points or volatility. These effects can be readily calculated when the distillations of the components are known, and the finished blends will follow a straight line relationship with extreme accuracy.

I feel that the effect of natural gasoline on the anti-knock value of the finished fuel has been slightly over-emphasized. It is entirely true that the usual grade AA natural gasoline has a good anti-knock value and will have its effect on the finished blend, but the refiner should not be misled into the idea that he can make a high grade anti-knock fuel equivalent to the anti-knock fuels now on the market simply by the use of natural gasoline.

Gravity is still important to a few who are selling their product on a gravity basis but is becoming less important as this requirement is dropped from ordinary motor specifications.

In looking over the above points, it will at once become apparent that there is no definite limit to the results that can be obtained by blending additional natural gasoline. Intermediates can be lowered, volatility can be increased, gravity can be raised and the anti-knock value can be increased within a limited range.

The negative effect that comes in at this point, is the vapor pressure whereby any increase over a pre-determined maximum will cause vaporlock and render the gasoline useless as a motor fuel.

I think I am safe in stating that all refineries are now primarily interested in marketing the best possible product with proper volatility and as high an anti-knock value as is possible with the materials at hand. With the volatility standard once set, the refiner is able to calculate the amount of natural gasoline needed, if any. In addition to this, he may calculate the quantity necessary to raise the finished blend to the maximum vapor pressure. If this quantity on any particular grade falls below the quantity necessary for volatility or any other intermediate points, a more stabilized product must be purchased. This enables the rough determination of the proper grade.

The more general case, is where the quantity necessary for volatility falls considerably below the amount necessary for vaporlock. Thus the refiner is given a choice of a maximum and minimum which can be used. This is where the cost comes in as he will certainly not use maximums under adverse price structures. The refiner is also interested in the uniformity of his product and will not consider changing his product daily to fit a changing natural gasoline market. Not only must the price of natural gasoline be lower than the motor grade, but it must not fluctuate out of relation to the motor grade if the natural gasoline manufacturer is to expect a consistent use of his products.

We must also consider the specifications of natural gasoline at this point, which are particularly indefinite at the present time.

Up to a year or so ago, a change in the natural gasoline specifications did not appear necessary even though the vapor pressure was not stated, and even though it was considered by the general refiner that the specifications were more or less arbitrarily standardized by the

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natural gasoline industry to suit their particular conditions.

It was fully realized at that time that different grades were preferable for certain purposes but equivalent grades were fairly constant in composition and intelligent blending could be carried on.

NEW FIELDS ALTER CONDITIONS

These conditions were altered by certain new fields coming in with gas of a high butane content, but improved efficiency in the gasoline plants, the manufacture of aviation and highly stabilized motor fuel blends and commercial solvents. The effect of these products was to create residual products which the natural gasoline manufacturer attempted to blend to the so-called "synthetic naturals" characterized by high butane content, high gravity together with high recovery.

Taking grade AA as an example, we may now receive materials with butane contents ranging from 20 per cent to 40 per cent, and with gravities ranging from the low 80's to as high as 91 and 92° A. P. I. Vapor pressures also vary under similar extreme ranges.

The papers presented this morning have given us various methods for our blending operation, but the question will at once arise as to what basis can be used by a refiner intelligently to carry out a blending program under these conditions.

This may be diverging slightly from the subject of the papers under discussion, but since none of the papers are specific in defining the commercial grades to be used, it seems a good time to mention the possible variations which are not only possible but probably under the existing specifications.

The refiner is particularly interested in the composition of the natural gasoline he is purchasing and should be assured of the approximate composition before the arrival of the material. When a refiner ships a car of finished motor fuel, the purchaser knows more or less definitely what he is to receive. There does not seem to be any reason why casinghead specifications should not be equally specific.

In reviewing this position, it would appear that specifications could be built around the butane and pentane content and the vapor pressure. This does not necessarily mean that a natural of high butane content would be the least valuable as it may be more valuable for certain blending operations. Each grade will seek its own price level based upon the law of supply and demand.

In Mr. Davison's paper, I noticed that the specifications committee has selected 140°F. with the vapor pressure as indication of the butane and pentane content. My personal feeling is that this temperature is perhaps too high and would not differentiate sufficiently between the components, and would make it possible to substitute butane for pentane in synthetic natural gasoline mixtures.

I trust that these few remarks will bring forth more discussion on the principles involved and the papers in general.

Marketing of Natural Gasoline

By W. K. WARREN
President, Warren Petroleum Company

COMPARATIVELY few people either in or out of the oil industry realize the growth and advancement that has taken place during the past 15 years in the natural gasoline industry. The fact that our branch of the petroleum industry is producing today 12 per cent of the total gasoline manufactured, reflects the rapid strides the manufacturers of natural gasoline have made. It is then with some apprehension that we discuss such an important phase as the marketing, or selling, of this vast amount of gasoline. Back in 1916, some of you will remember, we had only two grades of natural gasoline. These grades were classed as raw casinghead, gravities 80-84 and 80-88, and water white. There were no other specifications.

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Our principal purchasers were The Texas Company and the Standard Oil Company of Indiana. These companies would bill their tank cars to the casinghead gasoline plants loaded with naphtha and the manufacturers would blend the casinghead and naphtha, load the cars and then ship the product to the refineries or distributing points designated. The price paid for casinghead at that time was what we considered a fair return, ranging from 26 to 32 cents per gallon with no tank car expense, outages or off specifications to consider.

The plants, with a few exceptions, were what we consider today as small plants, ranging from two to eight thousand gallons per day. One of the larger manufacturers during this period was Douglas W. Franchot, now deceased, and when he began to ship casinghead in the raw state (not blended) the railroads were skeptical of its nature and thought of it as liquid dynamite, hazardous to both life and property. To convince them otherwise, Mr. Franchot bargained with officials of the Frisco Railroad that if they would accept the shipment he would ride a tank car loaded with casinghead from his plant at Keifer, Oklahoma, to its destination at Neodesha, Kansas, and according to Mr. Franchot's own words he was in doubt about his safe arrival at Neodesha. However, he arrived safely and since that time there has been little difficulty in shipping casinghead, now better known as natural gasoline.

We have had several changes in specifications since 1916. About 1922 the grades were changed from A to F and again in 1926 the grades were changed to the present specifications, adding doctor and corrosion test in 1928. The largest percentage of natural gasoline manufactured is Grade AA specifications, which is probably 85 per cent; the balance, or 15 per cent, is divided between A, B, BB and C grades. Compared with the total, B and C grades are practically obsolete today. Climatic and market conditions of course play an important part in the manufacture of the various grades and their percentages.

WHY PRICES FLUCTUATE

Some of you who have only been in the natural gasoline business for a few years might wonder at times why we have not been able to maintain a higher price for our product, and why the market in the past was so erratic; and as Chic Sale's Elmer says "I'll tell you why." Back in the early days of 1916 manufacturing gasoline by the compression method was a small business known only to a few, while today it is a major branch of the oil industry. From the year 1916 we have had a steady increase of natural gasoline production, and like crude oil production, straight run gasoline and other products, we have advanced at times ahead of our market consumption, which of course, caused low prices. To illustrate the growth of our industry, in 1929 our total production of natural gasoline, or 52,271,000 barrels, was 10,000,000 barrels more than our total automobile consumption of straight run gasoline in the year 1916. Of course it is true that we have more outlets for straight run gasoline now than we had 14 years ago, but at the same time our increases in production have at times been at such a rate that we have not been able to maintain a healthy condition in the industry. For instance, some of the manufacturers have, in years gone by, resorted to putting their production into crude oil lines for lack of a market. In the latter respect, and excepting California, we do not believe that this condition has existed with any manufacturer since March, 1928, unless it was to the buyer's advantage.

Our chief market for natural gasoline is with the refining companies that use our gasoline for blending

with their products, and inasmuch as the refineries are able to consume only a certain quantity at a certain price, we have been forced to find other outlets. In securing other market outlets it has been necessary to change the manufacture and specifications, such as removing the lighter hydrocarbons, propane, butane, etc., and at this time results have been quite satisfactory, yet our market today for these by-products has not grown to the extent of improving the price of our regular grades of natural gasoline.

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About 10 years ago we shipped natural gasoline to all parts of the country, even as far as California, but in the past few years we have not only lost our business in California but California has practically eliminated our tank car movements to the Eastern seaboard by their shipments of cargoes of natural gasoline to this market. Somewhat the same condition prevails in West Virginia territory, with the exception of cargo shipments. That is to say, the West Virginia manufacturers were supplying some of the larger users before California manufacturers were shipping cargoes. Since these purchasers are buying their material almost one hundred per cent from California, the West Virginia manufacturers have been forced to market their product to smaller consumers in the East, competing or underselling our Mid-Continent manufacturers. As West Virginia freight rates are much cheaper than freight rates from Mid-Continent areas, our shipments to Ohio, Pennsylvania and the eastern states have been greatly curtailed. This leaves us today with a market to foreign countries, mostly for a stabilized gasoline, a small amount of coastwise trade, the domestic refiners and jobbers in the Mid-Continent field and Standard Oil Company of Indiana territory.

NEW OUTLETS NEEDED

We must accordingly know our potential production and see what our present market territory will absorb. Estimating a total of 60,000,000 barrels of natural gasoline that will be manufactured and marketed by natural gasoline manufacturers in the United States in 1930, it is interesting to note that this production is divided into three main groups, i.e., the Mid-Continent, which produces the largest amount, or 53.4 per cent of the total, while California will manufacture 38.6 per cent, or the largest amount for any single state, while the balance of the country will produce eight per cent. Having made an allowance for an increase of nine per cent in the above figures, the Mid-Continent field should have a production of approximately 32,040,000 barrels; California 23,160,000 barrels and the balance of the country 4,800,000 barrels of natural gasoline. It might be of interest to know that this production of natural gasoline plus benzol, and 169,000,000 barrels of gasoline supplied by cracking operations, will represent a total of 229,000,000 barrels, or nearly one-half of the country's gasoline requirements.

Since the natural gasoline industry furnishes such a large amount of gasoline and is such a factor in the petroleum industry, any improvement in the method of marketing or development of new outlets should be given serious consideration. Taking into consideration then the domestic refiner, we find that there are many refiners today who would use increased quantities of our product if they were assured that the material would never exceed a certain price delivered at their plant. However, since the law of economics must prevail, no manufacturer desires to guarantee the refiner an absolute profit with perhaps a loss to the manufacturer. The value of natural gasoline, of course, varies with the exporter and the domestic refiner and while the former can afford to pay more for our product, it must be kept in mind that the price the domestic refiner can consistently afford to pay is the price that should prevail, for it is the domestic refiner who purchases the largest amount of natural gasoline produced . The refiner contends that it is unprofitable for him to use natural gasoline of present specifications if the cost of our product is higher than he is obtaining for U. S. Motor at his plant.

Another contention is that he must sell his product without natural gasoline unless he can make a profit over and above the profit he receives for his own product. Otherwise, he would become only a salesman for natural gasoline without profiting thereby. On the other hand, the natural gasoline manufacturers believe that the improved quality of the refiners gasoline in volatility alone should warrant more than this, especially since much of the natural gasoline used is in the refiners premium fuel rather than U. S. motor. But we must face the fact that the increasing volume of natural gasoline available to the refiner is not conducive to a strictly seller's market and until such time as the refiner is convinced that our contentions as to the value of natural gasoline are true, is it not better to encourage the constant use of our product by meeting him at least half way in the matter of price?

The Mid-Continent division of our industry has, with the splendid leadership of the largest manufacturer in the business, accomplished much in stabilizing the price of our product during the past year and the sentiment among several manufacturers who were reluctant before has now changed and more thought is being given to increasing storage facilities for their product. Much more good could be accomplished by the Mid-Continent manufacturers if storage for only 15 days production was installed at each plant. Of course storage for one month's production would be of considerable help

TABLE NO. 1
Natural Gasoline (1st 3 Months)
(Thousand Gallons)

	Marketed Production		Used at Local Refinery		Other Uses or Imports	
	1929	1930	1929	1930	1929	1930
Eastern	35,016	31,964	59,388	65,940	a24,372	a33,976
Okla.-Kans.	158,557	156,387	35,070	50,064	b123,487	b106,323
Texas	88,804	115,821	93,450	108,444	a4,646	b7,377
La.-Ark.	23,126	28,721	66,402	54,180	a43,316	a25,459
Rocky Mt.	10,262	11,317	13,818	14,574	a3,556	a3,257
California	173,773	208,671	151,620	166,026	b22,153	b42,645
Totals	489,538	552,881	419,748	459,228	b69,790	93,653

(a) Imports. (b) Exports or other uses.

and would be the means of stabilizing the market and preventing ruinous prices during a slow period. There is today entirely too much natural gasoline being marketed and sold at prices below the cost of production due mostly to insufficient storage at gasoline plants. The result of added storage would mean that the manufacturer could ask a fair price for his product in proportion to the price of export and domestic gasoline.

MID-CONTINENT MARKET RESTRICTED

In analyzing the shipments and consumption of natural gasoline in the various states for the first three months of this year, the Bureau of Mines reports show some very illuminating facts. For instance, there were 66,000,000 gallons of natural gasoline used by our eastern refineries in excess of the amount manufacturers in the east were able to produce. These figures show the bulk of this gasoline was purchased from California. Further details regarding these figures are shown in a condensed form, Table No. 1 of this paper. We believe these figures will be of interest to you, in that it shows conclusively that the marketing territory for the manufacturer as well as the refiner in the Mid-Continent field is being restricted.

We could go on in detail for some time discussing the changes that are taking place, but more important is, what are we doing about it? We all know that California is and will continue to be manufacturing larger quantities of natural gasoline, and since this is a fact we must think ahead and prepare for the future. The refiners with their cracking processes and recovery plants are becoming more and more independent of the natural gasoline manufacturer each year. The speaker here makes the prediction that the Mid-Continent natural gasoline industry will within the next five years be marketing the bulk of their gasoline as a stabilized product. No operator can continually manufacture gasoline at a loss, and this is what the majority of the small manufacturers have been doing for the past two years. Regardless of the progress that has been made in the developments of new products from natural gasoline, we are only on the threshold of the possibilities for our industry. Realizing that it will take years to gradually broaden our markets, both foreign and domestic, for a premium grade of natural gasoline, we must continue to develop our present outlets until such a time as we will not be dependent entirely on the domestic refiners to utilize our product, perhaps at a price below our operating cost. This is no condemnation of the refiner. If he feels that our product must be delivered to his plant at a certain price, depending on what he receives for his finished material, he is justified in protecting his own interest.

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In the meanwhile, a great deal has been done by this association to dispel the ignorance and antipathy of the refiner for natural gasoline and more constructive work is yet to come from the same source, but the fact still remains that their use of our product is almost directly proportionate to price. This change, of course, must and will take time, but much progress has already

TABLE NO.2.

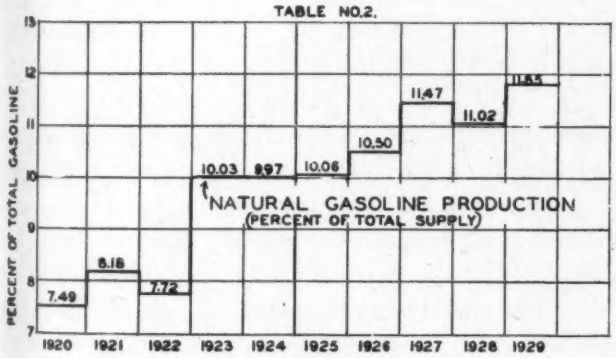


TABLE NO.3.

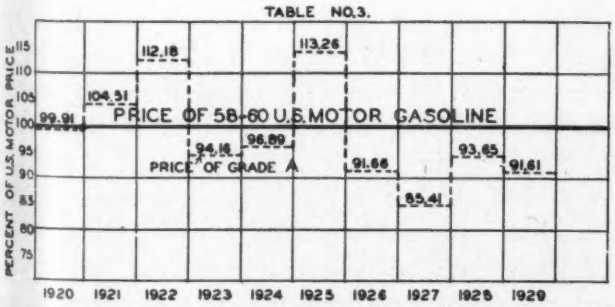
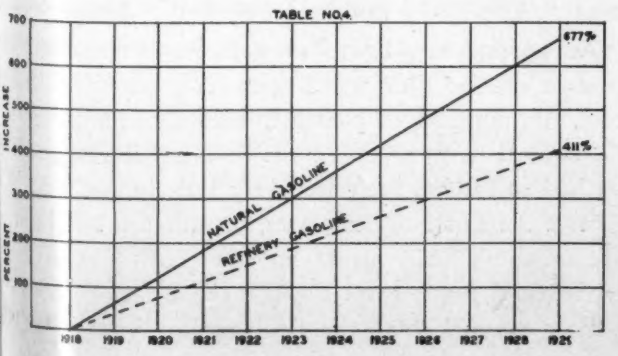


TABLE NO.4



been made by several leading manufacturers. Central stabilizing plants have been constructed by several companies interested in broadening the market for stabilized natural gasoline, and while this is only the beginning, the results have been very beneficial to the industry as a whole, for as some manufacturers have been slow about installing sufficient storage facilities, they have likewise been forced to dispose of their product at low prices to those manufacturers better equipped to handle the gasoline. The market for the by-products of natural gasoline is gradually widening and when the industry realizes more fully that the product they are now making and selling at a low price is a valuable petroleum derivative and can be used in time at premium prices, then will more effort be made to manufacture a product that will command a higher price.

In summarizing the above remarks; to improve our market, first, we should therefore endeavor to build more storage at those plants where storage is inconspicuous and which would avoid to a certain extent moving gasoline on a distressed market; second, we manufacturers should give more serious thought and consideration to the stabilization of our product and the market for the finished gasoline; third, to develop our present possible market outlets until such a time as the demand for stabilized gasoline will absorb our excess natural gasoline production so that we may enjoy a better return for our product.

We wish to mention here that in addition to Table No. 1, we have compiled figures showing for the past 10 years, beginning 1920 and ending 1929, the percentage of natural gasoline production each year to the total supply of all gasoline, which is shown in Table No. 2. Table No. 3 shows the price of natural gasoline in relationship to 58-60 U. S. motor gasoline for the same period of time. Table No. 4 illustrates the total per cent of natural gasoline increase as compared with refinery gasoline for the past 12 years.

Before concluding, it might be of interest to know that there are about 14 companies who market natural gasoline direct in the Mid-Continent field. Of these 14, six companies control the major portion of the total output. The remaining eight control directly or indirectly approximately 1000 cars per month. As a whole the integrity and character of the men engaged in the sale of natural gasoline is as fine and upright as any group in the oil business. However, there is one general weakness among sales managers, and that is too much reliance on the prices being reported by one of the leading oil price publications. The fault is not that of the publication but the individual who relies on the publication to tell him what to quote for his product. In other words, it is a case of the tail wagging the dog instead of the dog wagging the tail.

The Natural Gasoline Industry In California

By O. WEAVER
Barnsdall Oil Company of California

CALIFORNIA has at present 138 natural gasoline plants in operation which are treating over 52,000,000,000 feet of gas per month, with a gasoline yield of 71,000,000 gallons. This is an average of 2,366,000 gallons per day, or slightly over 3.7 gallons per barrel of crude oil produced daily, which is approximately 630,000 barrels. Certainly this has grown to the stature of a major industry and the intent of this paper is to give a short resume of the general conditions being met with at the present time.

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The state now has 36 producing fields, with another discovery, Venice, in the process of development, and a total of 12,695 wells, of which 3060 are shut in; giving the 9635 producing wells an average daily production of 65 barrels. Of the shut-in wells 2672 are old pumpers in the San Joaquin Valley, and were they on production, the average production per well would be materially decreased. The oil gravities range all the way from eight A. P. I. in the Santa Maria district, to 61 at Kettleman Hills, with the principal producing methods being natural flow, gas lift and pumping. The average gas volume per well for the state is 171,000 cubic feet per day, giving a gas oil ratio of 200 cubic feet per barrel of oil. Ratios of 1000 to one for flowing wells, and 500 to one for gas lift are generally accepted as ideal, but three fields in the state, Santa Fe Springs, Ventura and Kettleman Hills are producing such excessive volumes of gas that the ratio for the state is raised to the above figures. These three fields are producing three-fifths of the gas and just one-half the natural gasoline in California at present. Kettleman Hills, with and over 300,000 gallons of gasoline, and while the most attractive proposition for a plant operator, nevertheless constitutes a big menace to the price structure and profits of the smaller plants.

An approximate figure on well production methods now in use is: Flowing, 30 per cent, gas lift, 10 per cent, and pumping 60 per cent. Production obtained by the swab is too negligible to be considered. The gas lift method so far has been used very little in any field except in the Los Angeles Basin, but there it has been a life saver for many plants, and the gasoline content of recirculated gas is surprisingly high, in many instances coming very close to the field average. Over 4,500,-

.000,000 cubic feet per month now being treated is recirculated gas.

PRESSURES AT WHICH GAS IS DELIVERED TO PLANTS

There is a great diversity in pressures carried on wells where gas is going to plants, since common practice is to carry the gas through the plant on tubing pressure as long as possible, and avoid installation of compressors. This can usually be done for one to two years, except where drilling is too congested, but has the bad feature of giving a smaller yield, since the gasoline content of the gas very quickly reflects changes in separator trap pressures. This pressure ordinarily is about 40 pounds, governed somewhat, of course, by load on the plant, and gathering line sizes. Producers of the state are very loath to having vacuum pulled on the well, or casinghead, itself, and when wells are placed on the pump they are still operated through separators, and enough pressure held thereon to put the oil into the tanks, or else the trap is elevated to permit the oil to gravitate over. This has caused many plants to have two, and sometimes even three distinct gathering systems. This is particularly true of the Santa Fe Springs and Long Beach fields, where there are several oil zones, and deeper drilling booms have followed depletion of the upper measures. Both are closely drilled fields, with a consequent rapid decline. At Long Beach, the vacuum systems run to about 12 inches, with an intermediate of 20 pounds, and a high of 50 pounds. Santa Fe Springs has vacuum of seven inches, an intermediate of 40 pounds and highs of 250 and even 500 pounds. This, of course, is accomplished by double trapping, and installing high pressure absorbers, gives greatly enlarged plant capacity with no loss of production, and without the necessity of additional compressor installations. Kettleman Hills plants are operating at 400 to 450 pounds, and by double trapping are averaging about one gallon per 1000 cubic feet.

GAS TRAPS AND THEIR OPERATION

The average gas trap installation for new wells is of 5,000,000 to 6,000,000 cubic feet capacity and 175 pounds pressure test. If the gathering line pressure is pulled down to 10 pounds, or below, separation is usually very good, but so long as 40 to 50 pounds is held on them, a vapor gathering system to the flow tanks is found profitable, since a flowing well will yield 12,000 or 15,000 feet of seven to 10 gallons gas per day. On the high pressure traps in use in some fields, pressure regulators are provided. After the traps are properly regulated, very little trouble is experienced except in case of tight emulsion.

Practically all gas processed in California is tubing gas, since casinghead vacuum is frowned upon, except in a few isolated cases, and is then very low, being pulled by single stage compressors only. Also, only two or three plants are treating dry gas, and in those instances the dry gas is residue from overloaded plants in flush fields, and will probably not be found profitable when the volume has declined. To operate a plant at a profit here, if single stage compressors are necessary, and assuming a yield of one gallon per 1000 feet, one should have at least 5,000,000 cubic feet per day. Of course, many small plants are running at a much lower production figure but usually are paid out and concerned now only with operating expense, or else have been put in for future development. The average gasoline content for the state is approximately 1.4 gallons per 1000, with the best of it by fields being slightly over two gallons, and the leanest about 0.9. Many individual wells will go much higher, even to five gallons, but the big gassers pull the average down. Not more than 5,000,000 feet a day is now blowing wet, and of the 1,700,000 cubic feet being processed, about 50 per cent is handled through compressors, the other half going through on well pressures. This fact in itself would seem to indicate that the state as a whole would have rather low prodction costs per gallon, but the fact is that most of the small plants, where overhead is high in comparison to production, have to handle their gas in compressors, so that a fair average cost would seem to range from three to 3½ cents per gallon, while over the past year the approximate selling price has been about 7½ cents.

PLANT RESIDUE GAS

It is a well known fact that considerable economic waste of surplus residue gas exists in nearly all flush pools, however, great efforts are being made by producers and natural gasoline manufacturers to find markets for such excess residue, and thus eliminate such waste. It is also well known that marketing any marketable waste product is of financial interest to both the producer and gasoline manufacturer, and such market opportunities are not overlooked by the industry, but many times create tremendous investments.

Most of California's natural gasoline plants have been built in the last 10 years, with the absorption type in general favor, in fact, compression plants scarcely exist. The only one recalled now is a small one at Fillmore, making less than 2000 gallons a day. Plant equipment is subject to constant experiment and improvements made. Many of the later plants are completely operated by centrifugal pumps, three and four on a shaft, and steam turbine driven, or else by motors, since all fields are electrified. This gives compactness and steady flow, though maybe not quite so flexible as reciprocating pumps. Much bad water is encountered, so that banks of shot multiple-tube heat exchangers and preheaters are preferable, as well as bent-tube sections for cooling. One bad feature observed is that in the town lot areas some plants are dangerously crowded, due to the small space available for a layout. Taking the state as a whole, the average production per plant per day is just about 16,500 gallons, with about 65 wells to each plant. However, in the heavy oil districts of Santa Maria and San Joaquin, the number of wells per plant is probably around 75, and in the Los Angeles Basin the number is 48 or 50. The life

NO PIPING

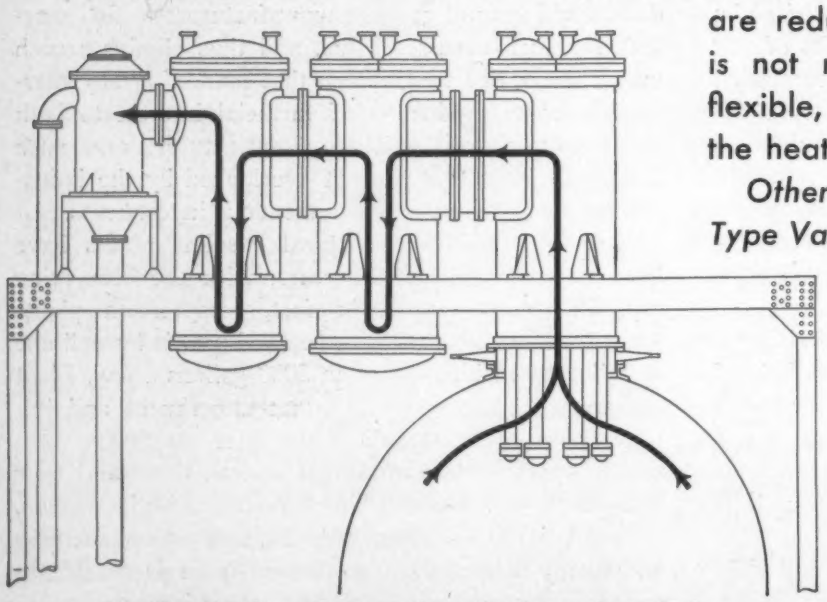
Less Back Pressure

THE HEAT EXCHANGERS shown here are for use in the vacuum distillation of oil. The first unit is bolted directly on top of the fractionating tower, and has the lower end of the tube bundle projecting into the tower. From the first unit the uncondensed vapors flow to the second, and then to the third. There are no constricted openings for the vapors to go through, and not one foot of vapor piping is required. The total pressure drop through this unit from the top of the tower to the vacuum pump will be a fraction of the pressure drop across the standard multiple unit horizontal heat exchanger separated from the tower by a long goose-neck connection. The elimination of intermediate connections also reduces the total length of welded joints in the vacuum system 50 per cent.

As these units are placed on top of the tower and supported by the same steel work, expansion and contraction strains due to changes in temperature are reduced and elaborate anchoring is not necessary. Only comparatively flexible, small diameter piping connects the heat exchangers with the ground.

Other advantages of the Leach Tower Type Vacuum Condenser.

Multiple tube bundles make possible fractionation of the overhead distillate from the tower. Slight discoloration, due to entrainment from the tower, is segregated in the first fraction, while odor from cracking and water from the steam used in stripping are



Showing the flow of vapors from the tower through the Leach Fracto Condensers to the barometric condenser.

Fracto Control TRADE MARK REG.

LEACH

Leach Fracto Condenser for vacuum service. This design is for use on top of the fractionating tower.

confined to the last fraction, leaving the intermediate fractions clean and well fractionated.

Other Leach Heat Exchangers are designed for all oil refinery services, including the condensation of corrosive naphthas at one extreme and cracking coil service with temperatures up to 800 deg. Fahr. with pressures of 1500 lbs. per sq. in. at the other.

NOTE: Independent floating heads.

All Leach designs are protected by patents in this country and abroad.

C. H. LEACH COMPANY

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LEACH Fracto Control TRADE MARK REG.

of an oil well in California is a most uncertain thing, and at the best only a guess can be hazarded. Let us put those of the heavy oil districts at 15 years, for many are older than that now, and still going, while we place those of the light oil districts at five years. Certainly many of them that are well located will last a much longer time, but edge wells which are completions, but soon go to water, greatly shorten the average life.

FRACTIONATION, TREATMENT AND HANDLING

Just about all natural gasoline made in California is fractionated. Only a little bit that is disposed of under old and long term sales contracts is not so treated, and it is impossible to sell any at present on contract that is not 90 recovery or better. The trend is ever toward higher recovery, as is evidenced by the states' newest field, Kettleman Hills, where all specifications are for 96, and where the raw product runs as high a specific gravity as 88. Rectifier column pressures run all the way from 150 to 250 pounds, with bottom temperatures from 225° to 280°F., and from 90° to 135°F. at the top. No gasoline is being treated for doctor and corrosion, as so very little sour stuff is made, and this is disposed of by mixing it in with crude oil. California is peculiarly fortunate in that nearly all of its product is shipped by pipe line. Out of a total production of nearly 2,300,000 gallons a day, only 180,000 gallons is handled by truck and tank cars, and probably not more than 100,000 gallons is moved in crude lines. Of the latter, 70,000 gallons is blocked into crude lines from Kettleman Hills without contamination, owing to the high gravity and light color of the crude. Union Oil Company has just completed an 81-mile six-inch white line from Kettleman Hills to tide water at Avila, and have an ocean loading line.

The Natural Gasoline Manufacturers Association of California is working just now at two problems, the first of which is our old friend a standard method for content test. The tentative recommendation at present is the charcoal 30-pound - 32° but with some doubt expressed as to its final adoption, and with gas analysis looming up, provided it can be perfected.

The second problem is that of a fair price base. Some time ago most outstanding contracts were changed so as to be based on Los Angeles posted tank-wagon price, but during the recent price war that was raised two cents a gallon, to care for differentials, without any real change in the wholesale price, so once more our base became a fictitious one. The plan now under discussion is to post a flat price for iso-butane free gasoline, but to accept a product up to three per cent iso-butane with a penalty in price, and all settlements made on gas analysis run on each shipment.

And so it is hoped that it won't be long now until, when we speak to a second party of that said stuff, natural gasoline, said second party will know exactly what we are talking about.

Natural Gasoline Industry in the Mid-Continent

By A. J. SCHLOSSER and J. E. DALE
Barnsdall Oil Corporation

THE gasoline industry started in 1904 in Forrest County, Pennsylvania. South Penn Oil Company installed a gasoline plant at a place named Porky. This name existed since the pioneer lumber days. There is no town there at this time. The nearest post office is at Mayburg, Pennsylvania.

Proceedings of Natural Gasoline Association

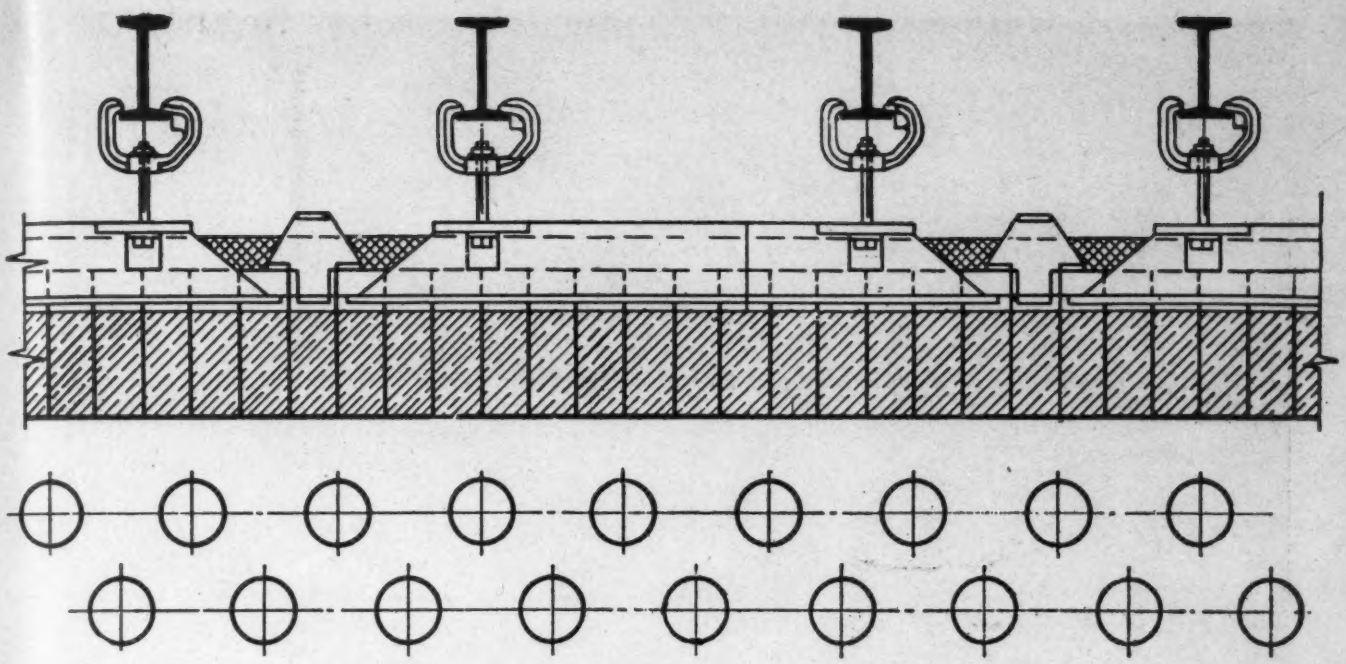
The plant was constructed under the management of William Rickards, then in charge of this district for South Penn Oil Company. The designs were furnished by Bessemer Gas Engine Company. The plant only had a production of about 200 gallons per day—very small, but the start of a great industry. There were practically no markets for the production at that time, and the progress of the natural gasoline recovery lay dormant for six or eight years, during which time dry gas marketing companies, along with governmental agencies, did considerable research work.

The automotive industry, rapidly growing during this same period, created a demand for gasoline, and the refiners' efforts were diverted from kerosene manufacture to gasoline. During this evolution, the natural gasoline industry began to grow rapidly, and during this same evolution has kept abreast of the times, continually improving its product, and is now a real asset to the oil industry, furnishing about 12 per cent of the gasoline requirements.

The gasoline industry developed to its present magnitude from its small beginning in 1904, to a production of 115,000 gallons per day in 1914, and will approach 7,000,000 gallons per day in 1930. In its earlier days, it was considered advisable to install gasoline plants on dry gas lines, later it was applied to casinghead gas from oil fields, and later the industry was burdened with the requirements of furnishing vacuum for the producers, and at present, the industry is a great convenience to the oil producer.

The gasoline manufacturer is expected to take the casinghead or recycled gas from the casingheads of wells, or gas traps, and return same at pressures suitable to the producer. In addition to these conveniences, the producer receives a very substantial revenue for his gas.

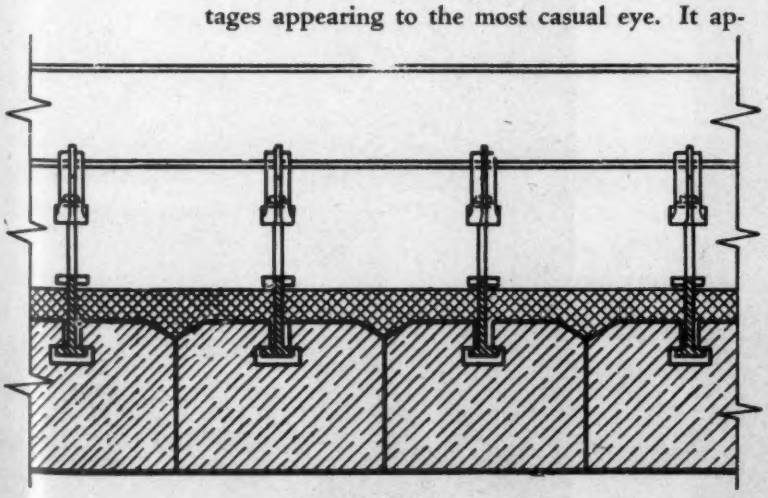
Co-operation, while it is continually improving between the gasoline manufacturer and producer, can still be much improved, not only between producer and gasoline manufacturer, but also between manufacturers.



Why Detrick Roofs Stand Up

The rugged simplicity of Detrick Still Roofs is easy to calculate from the cross-sections here shown. It is *not* so easy to see all the other reasons why Detrick Roofs stand right up to their work, nor why they are so often given the *chance* to "do their stuff" by experienced refinery engineers.

Sometimes they get this chance on earned reputation—quite as often, perhaps, through advantages appearing to the most casual eye. It appears almost at once that no forms are needed for erection; that assembling can be done from the top of the furnace; that each row of tile, being independently supported, is easily accessible for independent inspection or repair.



It takes a second look to see that this arch is suitable for use on a roof of reasonable inclination; that it can be used with or without insulation; that alignment is always assured; that rapid expansion or contraction is anticipated and evenly absorbed without strain.

It takes actual experience, perhaps, to grasp the full significance—the positive safety—of a design in which extra-deep, extra-heavy hanger castings are *never* buried, hence are always cool, always conducting heat away from the interior of the refractory.

These are only a few of the reasons why Detrick Roofs *do* stand up. When may we tell you the others?

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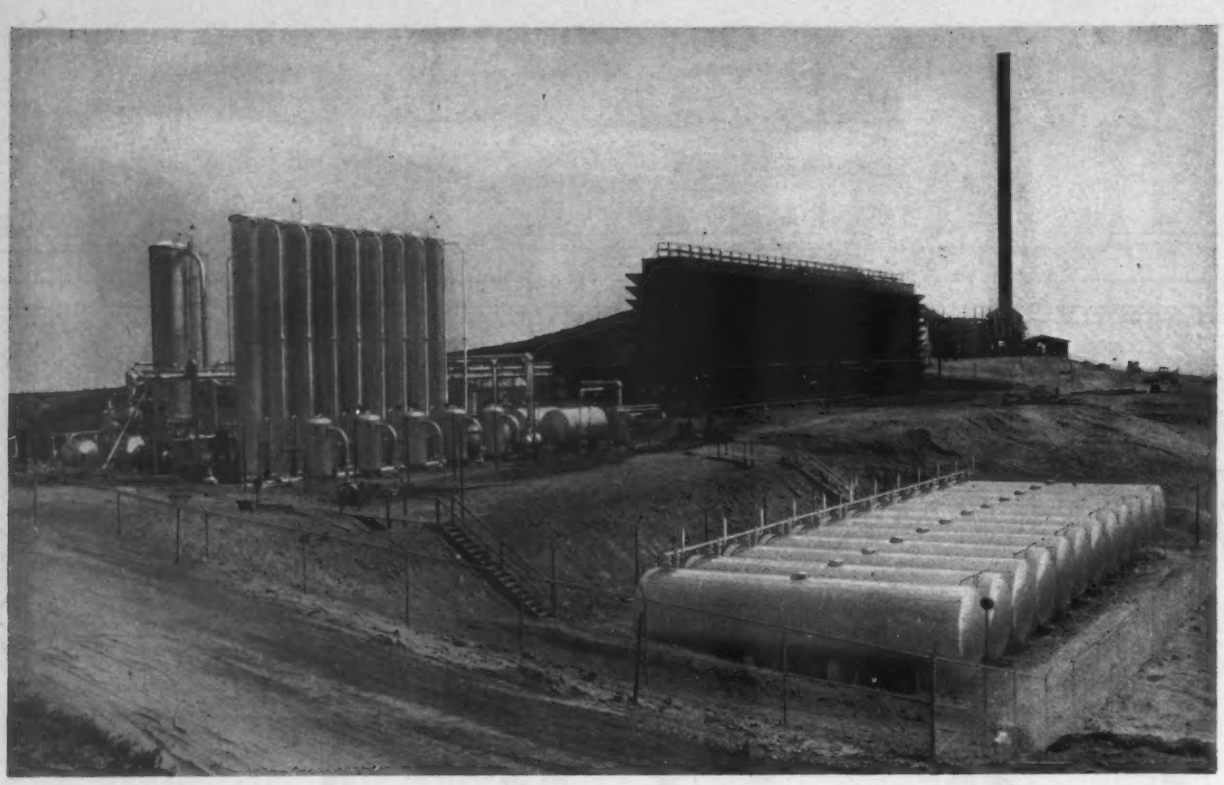
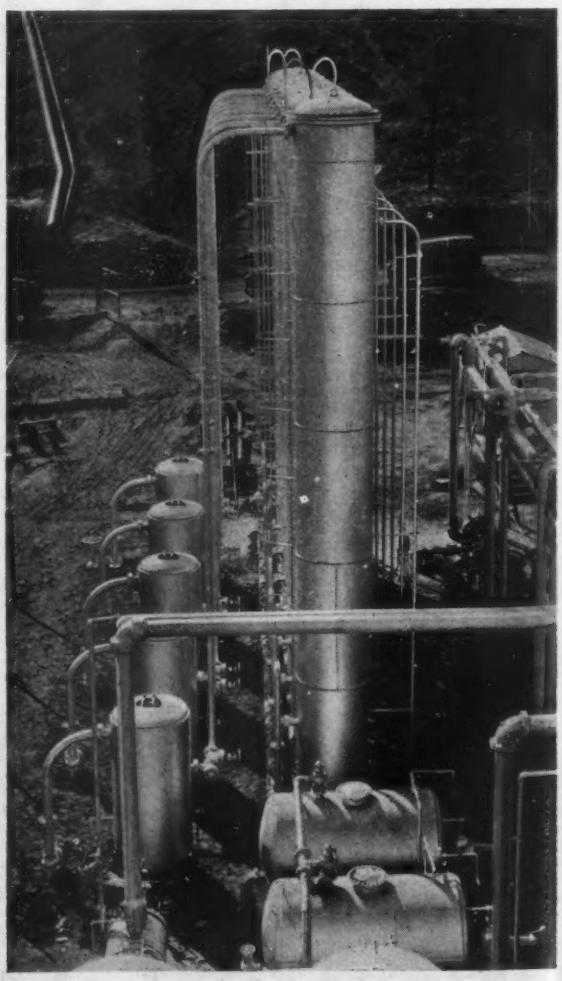
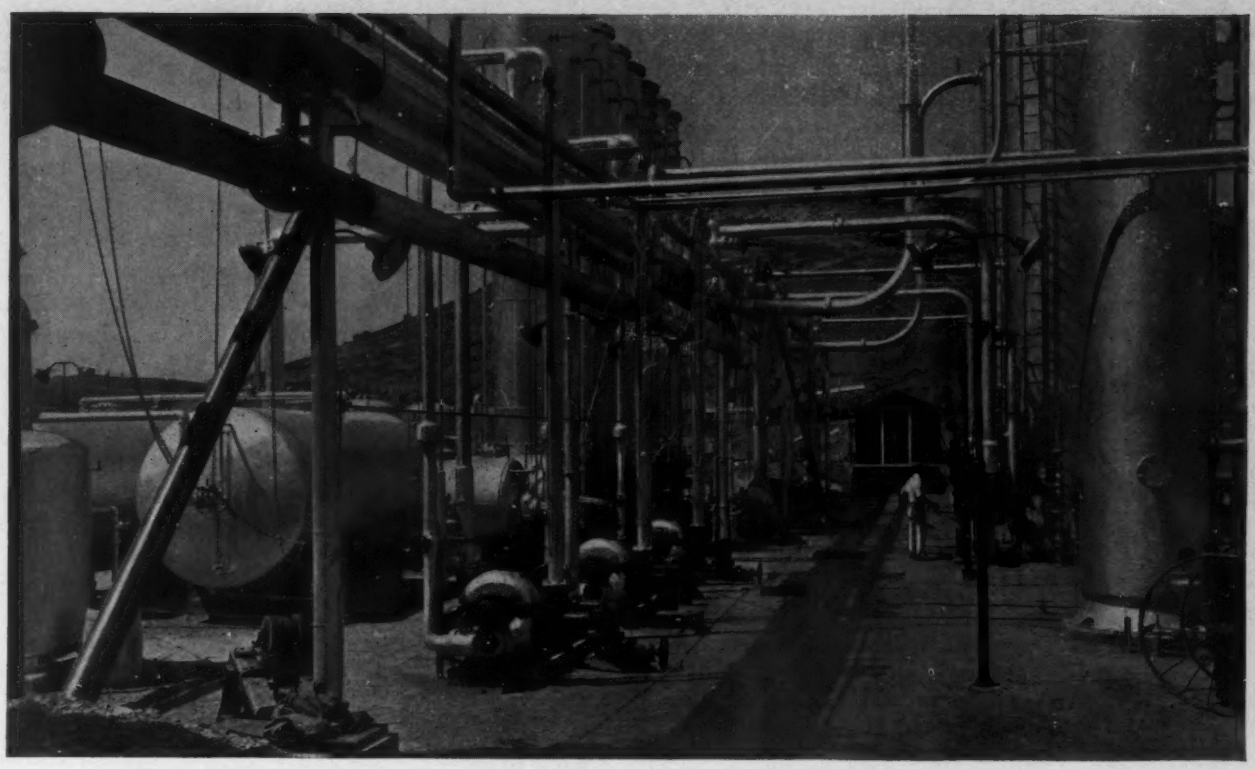


General view of Foster Wheeler natural gasoline absorption plant. The Foster Wheeler louver type cooling tower is shown in the center with the H.R.T. boiler plant at right. The boilers are fitted with Foster Wheeler superheaters and water-walls.

(Right) Nine absorbers with scrubbers at the left and fat oil tanks in the foreground. The absorption towers have flanged heads, sectionalized bubble trays and vapor connections from the side, so that top may be removed and trays taken out.



(Left) Fractionating unit, showing internal heater coils which give practically the same temperature to lean oil leaving the still as the fat oil entering the still.



Center aisle thru the plant, showing symmetrical arrangement and ample provision for accessibility to all of the equipment. Stabilizer tower is shown in the right foreground. Main oil and water pumps of the centrifugal type are driven by steam turbines operating at 150-lb. pressure and 125 deg. F. superheat.

100,000,000 Cu. Ft. per Day High Pressure Gasoline Absorption Plant

The Foster Wheeler natural gasoline absorption plant here illustrated, consists of a boiler plant, cooling tower, storage tanks, a 75,000 gallon per day stabilizer and two units, each having a capacity of 50 million cu. ft. of gas per day.

The first unit was completed in 39 days from date of contract—the second unit 26 days later, including delays caused by rain and snow. The plant was running smoothly within three hours after starting oil circulation. This is the shortest time in which any plant of this size has been built.

Since starting up, the plant has been continuously producing gasoline of 87.5 deg. A.P.I. gravity and giving an Engler recovery of 96.5 per cent.

A complete description of this plant at Kettleman Hills, California, will be mailed upon request.

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FOSTER WHEELER

For example, in flush fields, the manufacturer is expected to receive the gas from a separator at each well. As depletion takes place, it has been customary to pipe four wells to one trap. The gasoline manufacturer must then remove his pipe from the four traps and connect to the one central trap. As depletion further proceeds, and the use of a trap is unnecessary, the wells are put to pumping and the manufacturer must then repipe to each well. This is a continually changing service that is very expensive to the gasoline manufacturer, and adds materially to his costs. By using a large trap, this duplication of field piping could be eliminated.

CONTROLS AND REGULATION

Automatic float controls and regulator equipment, ordinarily used on traps for handling oil and gas individually, to make proper delivery of both to the required destination, if properly cared for will fulfill the requirements, however, all automatic apparatus have reasons for failing at times. Swab rubbers, and other foreign matter interferes with the proper function of float valves, especially as to the oil delivery requirements from the trap, and I have yet to see the first casinghead gas gathering pipe system that is not occasionally flooded with oil, in flush fields. This is a loss to the gasoline manufacturer, and sometimes even causes surface damage in draining the oil from the gas lines. By the use of strainers, which can be cleaned without interference to service, much of this lost oil can be saved. Also, co-operation and daily attention to this sort of equipment in nearly all cases can be much improved, and the cost of manufacturing gasoline reduced.

There are many things entering into the cost of manufacturing casinghead gasoline when considered from the standpoint of each individual plant; the method of production, whether it be absorption, compression, or charcoal; a plant on flush production, reasonably well settled production, or badly depleted conditions; the volume of gas per well; the content of the gas per lease or farm on which the gas is metered; the number of meter installations for each individual plant; the number of wells connected to each plant, necessitating more or less field piping, as the case might be; the intake pressure at which the plant is operated, whether it be operated on well pressure or vacuum.

MID-CONTINENT COSTS

Some of the plants considered are operated on extremely high vacuum, necessitating practically as much horsepower as when the production was flush and gas plentiful, which also necessitates practically as much operating expense, including machinery, upkeep, and the employment of labor, as was necessary during the period of flush production, and as a consequence, increasing the cost per gallon, where conditions have reached the depleted state. The cost per gallon for each individual plant, and the average cost for the entire Mid-Continent field, would be a long drawn out process if arrived at definitely.

In preparing this article, I have chosen a group of plants situated in Kansas, Oklahoma and Texas, as a basis for calculation. These plants are fairly representative in proportion to size, construction, age and operation, ranging from one to 15 years old, operating on production ranging from flush to badly depleted conditions, volumes varying according to term of years in operation.

In this group of plants there are two in Kansas, 46 in Oklahoma, and eight in Texas. Their intake pressures range from well pressure alone to 27 inches vacuum. Their volumes range from the very small to a relatively large capacity plant. The area covered by each individual plant ranges from one well to 422 per plant, and connected to these plants is a total number of 5096 wells, or an average of 91 wells per plant. In this group of 5096 wells, there are about 60 flowing natural, about an equal number on gas lift, also some 50 wells swabbing, the balance being pumpers.

These figures represent the cost of production for the year 1929. Production cost includes everything that goes into the expense of manufacturing gasoline, including depreciation. Also, the revenue derived from the sale of residue gas has been computed and credited back to the cost per gallon, leaving the net figures the actual cost of 56 plants in question for the past year.

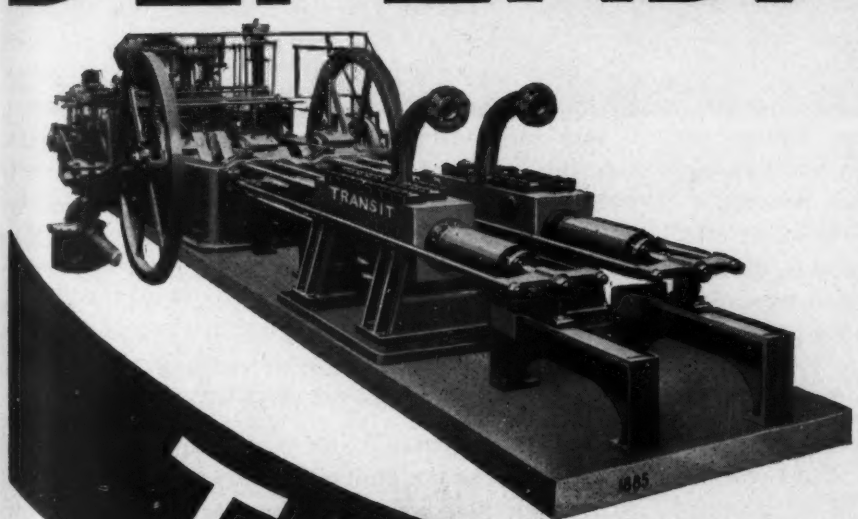
The average gas volume of each plant was 200,225,000 feet per month. The average content 1.6 gallons per 1000 feet. The average plant yield was 320,970 gallons per month, or 10,673 gallons per day, and the average cost per gallon was $.0574.

In the Mid-Continent area, of which Kansas, Oklahoma, Texas, New Mexico, Louisiana, Arkansas and the Rocky Mountain region, which is usually classed in the Mid-Continent field, we have 2,663,684 acres producing casinghead gas. On the West Coast there are 93,694 acres. In the Mid-Continent field for the month of March, 1930, there was produced 111,000,000 gallons of gasoline. On the West Coast there was produced 70,000,000 gallons of gasoline. The Mid-Continent area, therefore, is producing one and one-half times as much gasoline as the West Coast, and covering practically three times the amount of area in order to obtain its production.

The total average production per month for the 56 plants used to establish these figures, was 17,931,057 gallons, with a yearly total of 215,172,684 gallons. This was manufactured at a cost of $12,350,091, and represents about 10¾ per cent of all the natural gasoline manufactured in the United States.

Figures asked for but reaching me too late for incorporating in this article, on account of not being complete on the entire subject, which a very large manufacturer of casinghead gasoline sent, tends to further substantiate production cost as presented here, with a tendency to indicate that unless careful management is employed throughout the entire Mid-Continent area, that manufacturing cost will run dangerously close to six cents per gallon for the year 1930.

STURDY FLEXIBLE ECONOMIC DEPENDABLE



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These pumps are so ideal that within a period of two years, they have become a great success for hot oil pumping.

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Outage

By EMBY KAYE
Skelly Oil Company

OUTAGE has been scored as an evil, a waste, a scourge, and what not. After considerable study I have come to the conclusion that it is a misnomer. If outage ever meant transportation loss, it certainly takes in a lot more territory today. In times past, outage was accepted as a matter of fact; of late it has been studied. A good deal has been said about outage in recent years and it is "in the cards" that something is about to be done about it.

Proceedings of Natural Gasoline Association

Whatever importance attaches to this subject, I take it, is economic. We are concerned not alone with transportation loss, for that is a thing of the past and negligible at present, but with plant losses, loading losses, and unloading losses. All of these losses are incident to "outage." As has been estibated,* gasoline equal to approximately six per cent of the gasoline transported in tank cars is lost each year to the extent of some seven millions of dollars per annum, or an amount representing, in itself, a fair return upon the total value of the whole natural gasoline production and approximately three per cent of the capital investment in natural gasoline plants. It is because of this dollar and cents importance of outage, then, that this subject has been kept before you for so long a time.

I am hopeful that the present practice of allowing outage will be outlawed in the light of the studies that have been, and are being, made with reference thereto. I want you to hope that the new specifications will be tied in with an outage code that will be in the interest of good economics and conservation, and yet work no irremediable hardship upon manufacturer or buyer.

I have hoped for some such solution of the outage problem and have so intimated in papers which have been carried in the trade journals. Now I ask your indulgence to quote from the reactions of a large buyer of our commodity, because I feel that in answering him I can more easily present the case of the manufacturer.

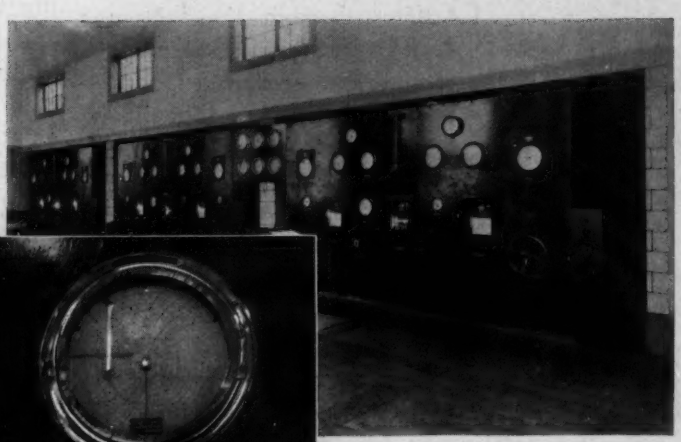
He says: "(1) The position of the buyer of natural gasoline is now and will continue to be that he will prefer the seller to stand the outage between the point of shipment and destination. Those from whom we buy are now willing to do so. (2) If the outage is abolished there will be an inequality in the loss the buyer will suffer because of loss in transit. This will arise by reason of the different grades of natural gasoline, some of which are more volatile than others. That is, the loss on a gasoline with a recovery of 90 per cent would be less than on a gasoline with a recovery of 80 per cent, and the consequence would be that the buyer of a low recovery product would stand a higher loss. The penalty against the buyer is not only in the loss in transit but he also suffers a heavy loss from a wild gasoline in blending it, storing it in his plant, and in shipping. There is a heavy loss from the time the buyer receives the product until the customer purchases it at the filling station. One solution of this problem is for the natural gasoline manufacturer to fractionate his gasoline to a sufficiently high recovery so the loss will not be excessive. He should certainly remove from the gasoline all the propane. (3) The loss to the natural gasoline industry would, if the allowance for outage were abolished, simply transfer the loss to the users of natural gasoline, and, until such time as the natural gasoline industry makes a reasonably stable product, it is very questionable whether it would be fair to transfer such a loss. I fully agree with the idea that any and all equipment that can be installed at a reasonable cost to lessen loading and unloading losses, as well as losses in transit, should be used, but even this would not save the buyer from heavy loss in blending, storing, and marketing a gasoline into which had been blended a wild natural gasoline full of propane or an excess of other highly volatile fractions."

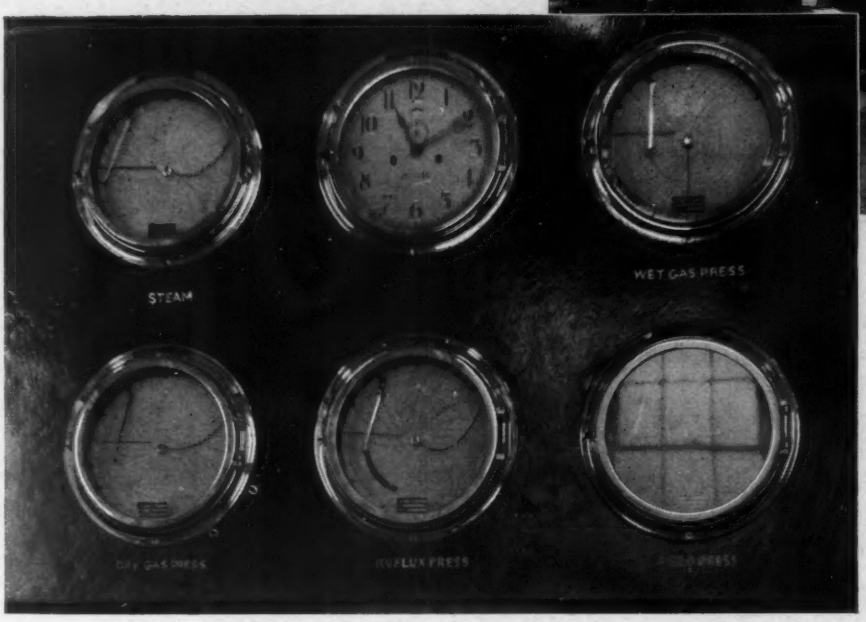
In the first place let me say unequivocally that I heartily endorse the position of the buyer as to the first part of the first point made by him. Unquestionably, the buyer will prefer that the seller stand the outage between point of shipment and destination. Moreover, I believe that the shipper should, by right, always stand the outage if outage means what it should mean — loss in transportation. But we must differentiate this loss from losses incident to unloading.

Transportation losses occur though the extent is negligible, and can occur only through failure of equipment. Safety valves on tank cars were adopted in 1915 and to my knowledge, at least, they have not since been improved. The same valve is used on Class III and Class IV cars, whether in heavy distillate or natural gasoline service. Frequent grinding of these valves and

BRISTOL'S Recording Instruments

Arranged For Flush Mounting





Above: Panel Board grouping of twenty-seven Bristol's Recorders in large Pennsylvania Oil Refining Plant.

At left: Close-up of central panel showing group of gauges used to record steam pressure, wet gas pressure, dry gas pressure, reflux pressure and feed pressure. Also included is Bristol's Gaugeboard Clock.

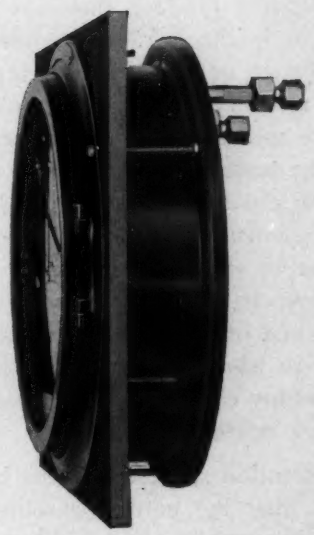
WITH the present trend toward centralized control, instrument panels reveal a decided tendency to "dress up". The *modern* board embodies not alone mechanical efficiency and convenience, but also a nicety of arrangement which invites the most critical inspection.

In line with this tendency it is but natural that discerning engineers in hundreds of plants are specifying Bristol's Flush Type Recording Instruments. As shown in the accompanying illustrations, such instruments present a clean-cut, attractive appearance—conveniently accessible for reading, changing charts, routine inspection, etc.

Case construction is dust-proof, fume-proof and moisture-proof. Single or multiple pens can be furnished to suit installation conditions. The inverted penarm ararrangement is standard.

And, of course, all instruments carry the usual Bristol's guarantee against mechanical defects.

Have Bristol's Service Engineers explain in greater detail the increased efficiency and savings attendant with correct instrument application. There's no obligation.



Side view of Bristol's 2-Pen Recording Gauge Model 43, which shows method of arranging instrument for flush mounting.

The BRISTOL COMPANY,

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expert inspection in recent years have practically eliminated this sort of failure. Of course, if the valve itself is improved, the cost of inspection and maintenance will be reduced in proportion. Occasionally, transportation losses occur due to faulty dome cover gaskets, and now and then a car will show up leaking through the bottom outlet valve. This valve has also received considerable attention of late and though a number have been tried out, there is none that is beyond criticism. However, the condition here is not serious and losses through this source are likewise negligible. But what losses do occur through any of these devious ways should be borne by the shipper.

Proceedings of Natural Gasoline Association

The buyer's point No. 2 is not dissimilar from the first point. If the cars are in good order there will be no greater loss in transit on one grade than on another. Tank cars are equipped to handle gasoline with an internal gauge pressure of 25 pounds, and up to this pressure there will be no loss at all on any character of gasoline. The loss to which the buyer refers in the quoted letter is not transportation loss by any manner of means. That loss is due to directed weathering of the product. That is the loss we are seeking to eliminate. We want to make it impossible for the buyer of 80 per cent recovery material to weather the material he buys before it is gauged for the account of the manufacturer. If the buyer of that material wishes an inferior product and pays less for it than for a 90 per cent recovery product, the buyer has no right to improve the quality of his purchase by weathering it at the expense of the manufacturer. If he wants the higher recovery product, he should purchase a material of those specifications. Any losses incident to handling after the material has been set on the buyer's unloading rack and after the car ceases to be in the custody of the manufacturer or the railroad, his agent, should be borne by the buyer. The extent of such losses will depend upon the characteristics of the product he is buying, and of course to a very large degree, upon the manner in which he is equipped to handle a product of the volatility characteristics of natural gasoline of even the more stable grades.

The solution suggested in the last part of paragraph No. 2, "that the natural gasoline manufacturer fractionate his gasoline to a sufficiently high recovery so that the loss would not be excessive," I am afraid would not be effective. I have witnessed what many others have, distillations of stabilized gasoline that showed 96 per cent recovery with no more than a trace of propane, which, nevertheless, had a sufficiently high vapor pressure to cause excessive loading and unloading losses. And there are buyers who prefer this particular product because it is butane packed to the limit.

NOT A NECESSARY LOSS

The first portion of the third paragraph quoted, to the effect that if the allowance for outage were abolished, the loss of the natural gasoline manufacturer would simply be transferred to the user of the product, is not at all my view of the situation. I believe that the loss is not a necessary loss and can be avoided. I want to see the user gauge his receipts of natural gasoline before he weathers the car, and if he does that, I am sure he will equip his unloading rack with facilities to weather the gasoline on his loading rack into his recovery plant. Thus the buyer will pay only for what he actually receives and the seller will avoid the loss of his commodity and freight thereon, if the vapors are allowed to escape into the air.

As to the rest of this paragraph, I should like to say only that no buyer is obliged to buy a "wild natural gasoline full of propane or an excess of other highly volatile fractions." However, if he chooses to buy such products, he should be willing to pay for the full gallonage of these fractions when they arrive at his rack. If the buyer is interested in a product similar to what it becomes after weathering at his unloading rack, he should buy such a product from the plant, for the plant is equipped to do the weathering much more efficiently than is a tank car. Why evaporate 100 or 1000 gallons and why waste freight? Is such a practice as the present one fair?

Now I should like to discuss in brief some of the causes of exaggerated transportation losses classified under outage, although these losses result either before or after the incident of transportation.

First, of course, comes the characteristics of the material which is transported. Natural gasoline is, even in its more stabilized forms, a highly volatile material, *manufactured and stored under pressure, and unless loaded, transported, and unloaded under pressure, some of the material will be lost.* The less stable gasoline will sustain greater losses if the material is handled without regard to physical laws. But a perfectly stabilized, propane-free "AA" gasoline, with maximum butane content and vapor pressure, cannot be transported during warm weather without large losses, unless it is under pressure all the time.

Often the volatility of stabilized gasoline is increased during storage, and a good part of the results of rectification nullified. It is the practice in most plants to maintain a pressure on storage tanks by means of residue gas in order to provide pressure to the loading pump suction, on the one hand, and on the other hand, to guard against pulling storage tanks in during cold weather as a result of the condensation of the vapors above the liquid in the tanks. The result upon the propane-free "AA" gasoline, after an exposure to residue gas for several days, may be set off in bold relief by an analysis of the gasoline, to-wit:

Compound	Before storage	After storage
Ethane		Trace
Propane	Trace	.8 per cent
Iso-Butane	2.24 per cent	2.91 per cent

Have you considered the application of Vapor Phase Refining in your plant? The chances are that you too will find it possible to

Increase your gasoline yields,

Improve your gasoline quality, and

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We will be glad to go over your own conditions with you and show you how.

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After longer exposure, gasoline has been found to absorb considerably more of the fixed gases than shown above. This is corrected in a number of plants by storing under natural pressure during all but exclusively cold weather. Loading pumps have been relocated with reference to providing sufficient head to suction lines, and in some cases a liquid seal has been provided for long-period storage so that only one tank elevated above the others was in contact with air or dry gas and served as a breather tank for the balance of the battery.

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LOADING LOSSES

Another source of increased handling losses charged to outage is to be found in extant loading methods. I take it that little natural gasoline is loaded today with the top of the car completely open. Not only is this practice of open dome loading hazardous, but the resultant loss of vapors is an unnecessary, and therefore wasteful, drain upon the industry. As a general rule, gasoline is loaded into tight cars equipped with special gauging devices, or through temporary dome covers, and a back pressure held on the car while loading, the excess vapors conducted through vapor lines into plant gathering lines, or if these are too distant, into a relief line where the vapors are vented at a safe distance from the track. In the case of some few companies no vapors are vented because enough back pressure is held on the car to condense or compress all of the vapors. In any of these methods, it is important that all air in the car be purged before pressure is put upon the car. Failure to do this imprisons about 600 cubic feet of air, some of which is forced into solution at elevated pressures. It has been found that it is of the utmost importance to leave vents open during the first period of loading, the exact time based upon the loading rate, temperature and experience. If, of course, the material is moving to a consignee that gauges the car without first releasing pressure and has facilities to recover the vapors, the matter of purging is not all-important. This applies primarily to cars loaded for general shipment, in which case dissolved air may become a source of loss of good gasoline if the consignee open the car for "weathering" and gauging. The vapor pressure of the gasoline has been increased, and when the air escapes from the car when the pressure is released, considerably good gasoline vapors are carried over mechanically.

It is important that the consignee handle natural gasoline shipments with regard for the consignor's interests. Failure to do so taxes the manufacturer perhaps more than any of the other losses sustained by him. The consignee is the custodian of the consignor's product and the latter relies upon the integrity of the former. Due care should be exercised by the consignee. He should avoid accumulations of loads during hot weather and should promptly unload cars received. In the event he is not equipped to weigh the loads, or use a U-gauge to ascertain the amount of gasoline in the car, or if the cars themselves are not equipped for gauging with one device or another, each car should be vented slowly, if necessary, to remove the dome cover, in order not to cause "boiling" within the cars as a result of suddenly reduced pressure. As soon as the cover may be removed, this should be done, a gauge taken and recorded, the bottom outlet valve opened if the control therefor is inside the car, and the cover immediately replaced. Every man at the loading rack must know that he is handling a material whose boiling point is, during the greater part of the year, lower than atmospheric temperature, and that, as the dome cover is removed or the vent opened and the pressure released, heavy losses are bound to occur.

VAPOR LOSSES

Samples of vapors released from tank cars in this manner, have been studied. From "AA" gasoline we found, by fundamental analysis, the following vapors in terms of G.P.M.:

Compound	Gallons per Cubic feet
Propane	.87
Iso-Butane	1.75
N-Butane	17.12
Pentane and heavier	7.62

These vapors are not materially dissimilar from the vapors leaving a car during the process of loading, where we found vapor of which these are representative:

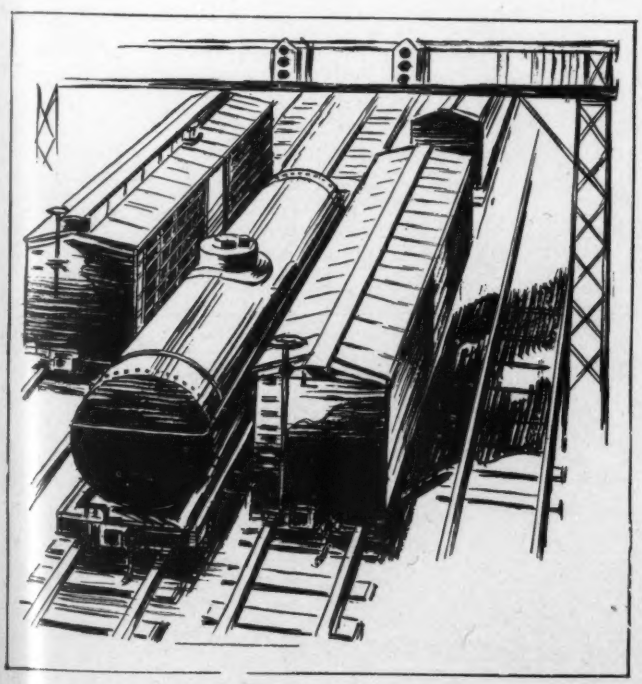
Compound	Gas Volume per cent	G.P.M.
Air	7	
Ethane	1.4	
Propane	18	4.87
Butanes	60.9	20.30
Pentane	10.9	4.03
Hexane plus		.72
Heavier	1.8	

In both cases, then, you see that the vapors, which issue from the tank car, are practically wholly valuable gasoline vapors, showing some 25 gallons of butane and heavier in every thousand cubic feet. While the propane may appear excessive in the loading vapors, you must appreciate the fact that the very small fraction of propane in perfectly stabilized gasoline will be released most rapidly when the gasoline enters the car under low pressure. As against the whole volume of vapors it is negligible. The fact remains that all of the vapors come from a merchantable grade of gasoline and the vapors in themselves are, by this examination, shown to be "gasoline" of themselves. They should, therefore, be saved, and accounted for.

The refiner, our chief buyer, has learned to know

You CONTROL Your Business Policies

WHY NOT .... the CARS in which your products are shipped



Never before have makers of packaged goods paid such careful attention to the design of their containers; because never before have these manufacturers realized so keenly that the customer's first impression of a product is based on the package in which it is presented.

To your customers the "package" of your product is the car in which it is shipped. Clean, modern, efficiently designed cars indicate a dependable product, a responsible shipper and progressive business policies.

Leasing your cars from North American, you assure yourself of a car supply always modern and in good condition. You enjoy complete freedom from "run-of-the-line" cars and obsolete equipment. You exercise the advantages of car ownership without the investment that actual ownership entails! Further details will gladly be mailed on request.

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our product. He does not lose as much of it as he used to in bygone days. As I go to refineries from time to time, I find that they are equipped with pressure storage tanks, into which natural gasoline is unloaded if there is no ready need for incoming shipments. I find that, instead of dumping a number of cars into a tank which has a little naphtha, until the material can be used, the natural gasoline is blended in the exact proportion required to make the finished product, and that the blending is accomplished in many plants in pressure tanks to assure a thoroughly homogenous product, and that in any event the naphtha or low gravity gasoline is brought into intimate contact with the natural gasoline. This blending, if not done in pressure tanks, is done in tight tanks so that the vapors may be saved, and I find that they are rather generally saved in vapor recovery plants along with all of the other vapors generated by the various processing in the yard.

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Witness the tremendous activity of the engineering and equipment businesses during the last twelve months and you can not fail to see how very saving the refiner has become. Read articles in the trade papers, or visit the refiner, and you will realize that he saves all but the smell. His vapor recovery systems recover from 3000 to 300,000 gallons per day, according to the size of his plant and the processes used therein.

REFINERY VAPOR SAVING

It is a long time since the larger refiner has allowed vapors, least of all, vapors from natural gasoline, to escape. When I first discussed this subject from this forum, vapor saving at refineries was the exception, rather than the rule. Today the reverse is true.

You have only to see the efficiency at some of the refiners' loading racks and vapor recovery systems to appreciate this. Partly because few cars are properly equipped and partly because of present outage practice, natural gasoline cars are vented before gauging, but in these plants the vapors are conserved in the recovery plant. In the case of some refiners, this saving runs into a neat figure. What I should like to see is universal saving of these vapors. And, after that, I feel certain, beyond a reasonable doubt, that all of the refiners will account for these vapors, that is to say, that they will credit the manufacturer with the total volume of gasoline laid down at the unloading rack of the refiner.

It is almost absurd to talk means for gauging and unloading natural gasoline in order to bring about a diminution in the "outage" charged back against the shipper when there are practical ways of gauging and unloading gasoline of any specification without loss. It is not important whether the stuffing box gauge, * * * an inexpensive arrangement, or peep-sites * * * are used, or any other practical means are employed, to make tight gauging possible. If you would have the refiner cooperate, it is up to you, as shippers, to equip your cars so they can be gauged and unloaded without removal of the dome cover. It is up to you to see to it that your product meets the specifications on which it is sold, and then the burden of the unloading, and loss incident thereto, if any, should rest upon the consignee. I vouch you that the outage question will then be history.

*SUMMARY OF ESTIMATES OF LOSSES TIED IN WITH PRESENT OUTAGE LOSSES

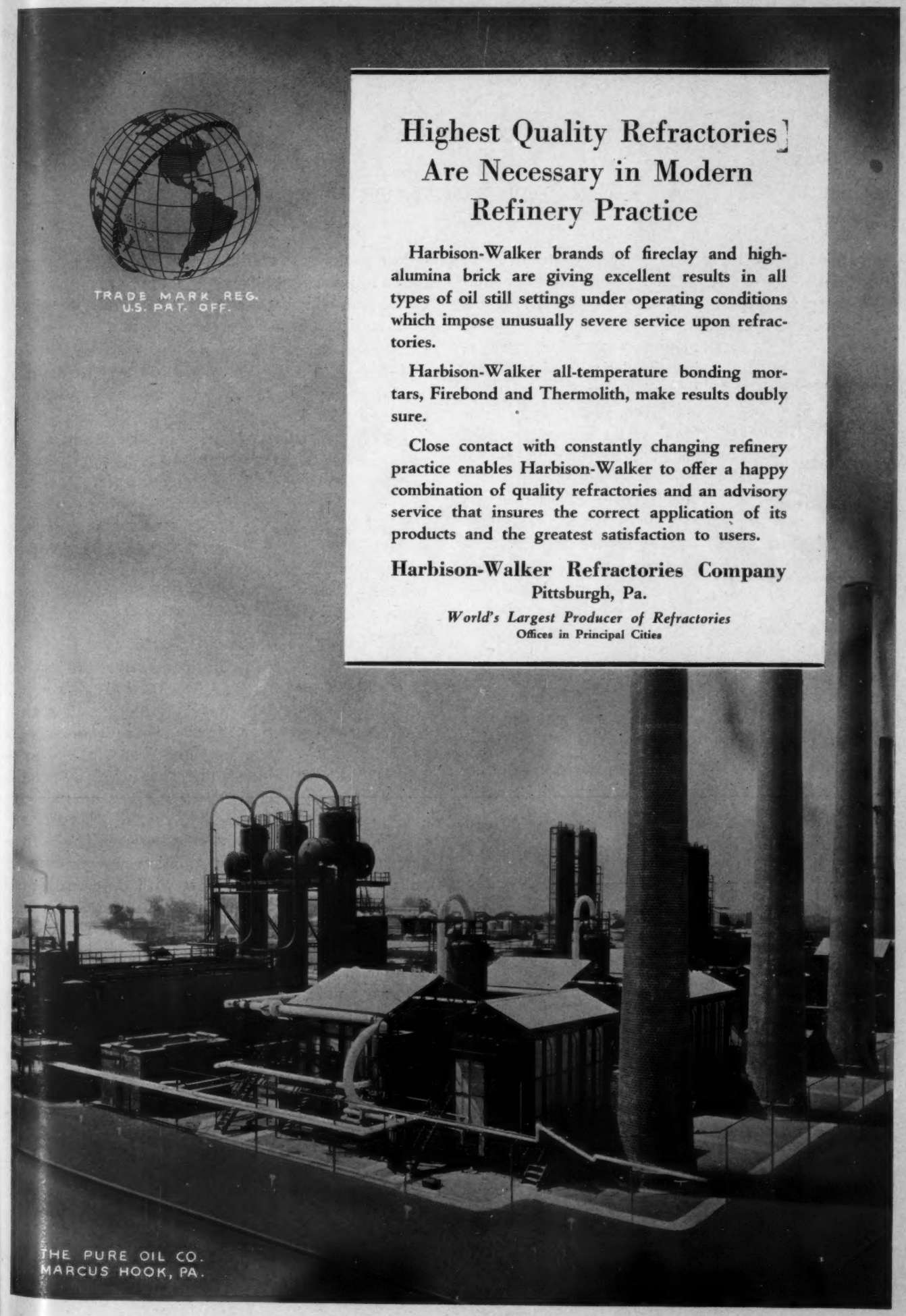
Total daily production in gallons.....	6,600,000
Gallons estimated shipped via pipe line..	2,600,000
Gallons estimated shipped via tank car..	5,000,000
Combined plant loading and transportation losses — 6 per cent or in gallons.	300,000
Market price per gallon	$ .065
Daily loss	$ 19,500
Annual loss	$7,117,500

The six per cent loss is, of course, arbitrary and subject to question by some operators. We arrive at it by figuring:

(1) 1½ per cent outage;

(2) 1½ per cent loss of production due to making less volatile gasoline than called for by specifications, in order to reduce loading and transportation loss, and

(3) Three per cent loading loss. Obviously, some manufacturers are experiencing half of the losses shown in the first item, but, in our opinion based upon observation and experience, their plant or loading losses are higher. Some plants do not extract enough butane and of course, may, for this reason, have a smaller loss on all three items.



Highest Quality Refractories Are Necessary in Modern Refinery Practice

Harbison-Walker brands of fireclay and high-alumina brick are giving excellent results in all types of oil still settings under operating conditions which impose unusually severe service upon refractories.

Harbison-Walker all-temperature bonding mortars, Firebond and Thermolith, make results doubly sure.

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Performance and Distillation Data

By DR. GEORGE GRANGER BROWN*

Proceedings of Natural Gasoline Association

ALTHOUGH there are, in this country, more than 25,500,000 registered automobiles consuming a total of more than 12,000,000,000 gallons of gasoline each year, surprisingly little exact information is available concerning the desirable characteristics of motor fuel from the standpoint of engine performance. It is generally appreciated that volatility is the most important property of a fuel since it determines the ease with which the motor may be started and the manner in which a car responds to the throttle. Knock rating or nondetonating characteristics are also recognized as the second important characteristic of fuels, since this property allows the fuel to give satisfactory performance in motors of high compression. This property is, however, to a limited extent, directly related to the volatility of the fuel.

In this discussion the conclusion derived from an extensive investigation of the relationship between motor performance and fuel volatility are summarized and presented in such a manner as to make clear the relationship between the A.S.T.M. distillation characteristics and motor performance.

A series of tests with the fuels whose A.S.T.M. distillation characteristics are shown in Figure 1 over the temperature range from —40° to 80°F. give the results as plotted in Figure 2. The straight line in Figure 2 was derived by Cragoe and Eisinger[1] from tests conducted on a motor equipped with a special fuel jet and cranked by a dynamometer. The data plotted in Figure 2 were obtained from a cold motor cranked by the electric starter supplied from the same battery as was used for ignition, and with the motor equipped with the standard carburetor. These data points fall as close to the straight line as do the original data of Cragoe and Eisinger.

STARTING TESTS

As has been frequently observed, starting was found to be more difficult at low cranking speeds such as 20 r.p.m. than at the higher speeds such as 140 r.p.m. However, when the air-fuel ratio supplied by the carburetor was computed for these different speeds, it was found that the same number of engine revolutions were required for a given air-fuel ratio at the carburetor regardless of cranking speed. Figure 3 indicates the relationship between engine temperature and A.S.T.M. distillation temperature required for a satisfactory start with different air-fuel ratios supplied at the carburetor. The percentages vaporized on the A.S.T.M. distillation at the indicated temperature are given in columns under the number of engine revolutions required to start.

For example, with an engine temperature of 10° F. and an air-fuel ratio of 1 supplied by the carburetor, the ease of starting is indicated by the percentage vaporized in the A.S.T.M. distillation at 140° F.; 6.5 per cent vaporized at 140° F. will allow a start to be obtained in 20 engine revolutions; 7.6 per cent vaporized will allow the motor to be started in 13 revolutions, and 10 per cent vaporized at 140° F. will allow the motor to be started in 7 revolutions at 10° F. Similarly at an engine temperature of —15° F., 6.5 per cent vaporized at 110° F. in the A.S.T.M. distillation indicates a possible start with 20 engine revolutions, and 10 per cent vaporized at 110° F. means a satisfactory start with 7 engine revolutions.

At low engine temperatures, oil or battery condi-

*Professor of chemical engineering, University of Michagan; director of research for the Natural Gasoline Association of America.

Trans. Soc. Auto Eng., Volume 22, Part 1, Page 1, 1927.

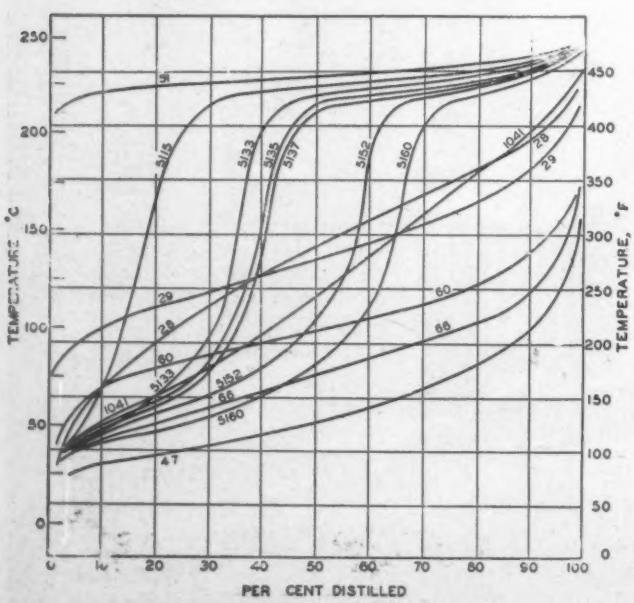
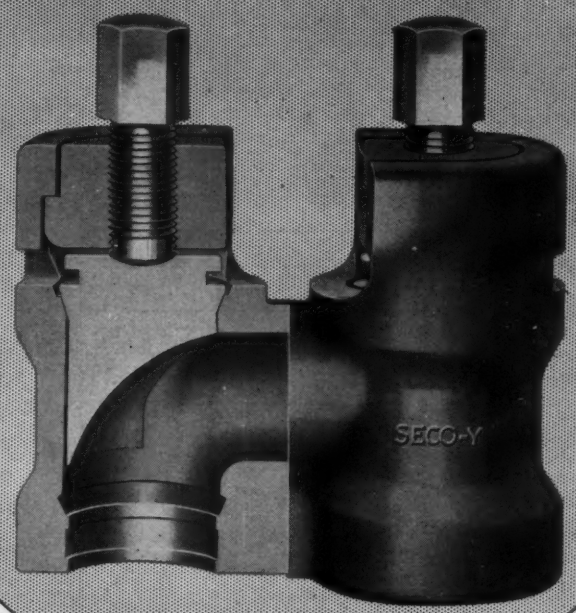
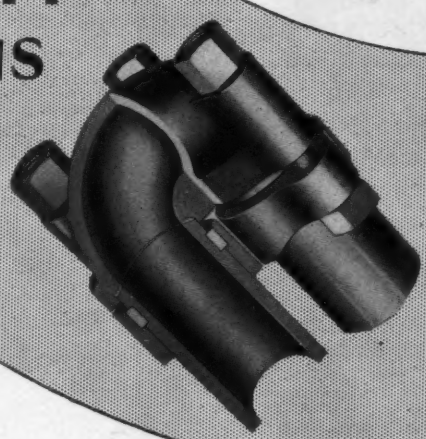


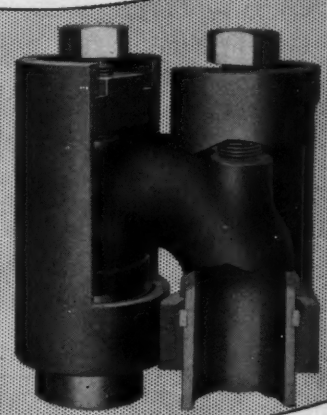
Figure 1

SECO RETURN BENDS



FURNISHED IN A VARIETY OF DESIGNS





SUPPLEMENTING the general purpose, bolted-on type A Seco Return Bend, Types A-1 and Y are offered especially for cracking still duty.

Type A-1 employs the time-proved split ring for locking the bend to the tube, which eliminates all tube rolling. It is a perfect stream line return bend—can be installed for a fraction of the cost of rolled-in fittings and can be easily removed for tube replacement, without disturbing the adjacent tubes.

Type Y is an improved rolled-in fitting that can be furnished in a variety of designs, either with the stream line plug, as shown, or standard plugs.

1. Type Y, an improved rolled-in fitting, designed for any service.
2. Seco Type A Return Bend, the original anti-friction bend. The method of locking the fittings to the tube affords advantages found in no other bend.
3. Type A-1, a modification of the Type A, especially suitable for cracking stills.

Complete information will be furnished upon request.

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DODGE STEEL COMPANY
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LOCOMOTIVE FINISHED MATERIAL CO.
Atchison, Kansas

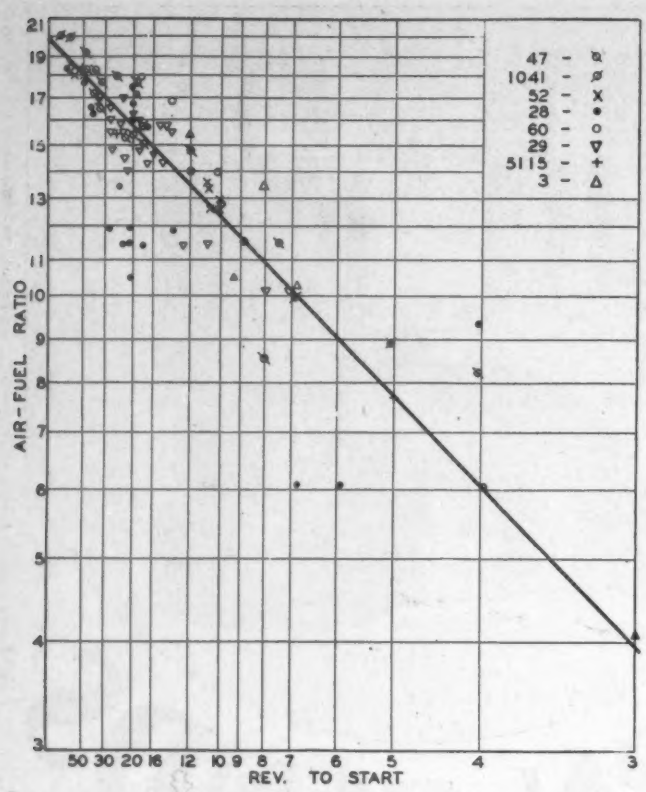


Figure 2

tions limit the maximum number of revolutions in which a start must be obtained. With a low viscosity oil recommended for cold weather operations, it was found impossible to crank the motor after the motor and battery had been standing in a cold room at —10° F. for two hours. In order to obtain a start with Fuel 47 at this temperature, it was necessary to dilute the oil with from 20 to 25 per cent of naphtha. When the oil was diluted to the extent of over 50 per cent, only 19 revolutions could be obtained from a fully charged battery at a temperature of —22° F.

For these reasons it is clear that possible starting at low temperatures demands a fuel so volatile as to start within 10 to 20 revolutions. At higher temperatures 10 or 20 revolutions may be considered an easy start. Furthermore, the lower cranking speed at the low temperature causes a more dilute mixture to be supplied by the carburetor, thereby making starting still more difficult.

As soon as the motor has been started, the manifold begins to distribute some liquid fuel along the walls of the manifold by the drag of the air-vapor mixture flowing through the manifold. When driving fairly constant speed along a level road, the velocity of the air-vapor mixture flowing through the manifold is fairly constant, and the liquid deposited on the walls of the manifold at the carburetor reaches the cylinders about the same rate that it is supplied by the carburetor. Under such conditions the air-fuel ratio supplied to the cylinders is practically the same as that supplied by the carburetor.

DRIVING CONDITIONS

During periods of acceleration, however, the amount of fuel delivered to the cylinders immediately after the throttle is suddenly opened is considerably less than that supplied to the manifold by the carburetor. The vaporized fuel carried in the air stream reaches the cylinders almost immediately as does the air. But the liquid fuel flowing along the walls of the manifold moves much more slowly than the air stream and does not reach the cylinders until sometime later (usually about four seconds). For this reason, during the period immediately after the throttle is opened, the cylinders receive all of the air passing through the carburetor, all of the vaporized fuel, but only that liquid fuel which was being distributed along the walls of the manifold before the throttle was opened.

These conditions have been considered by the manufacturers of carburetors, and the modern carburetor is so equipped with accelerating devices that an extra charge of gasoline is injected into the manifold whenever the throttle is suddenly opened. This, in effect, is the same as supplying a richer mixture for a few moments after opening the throttle. If the carburetor is adjusted to deliver an air-fuel ratio of 12 to 1 under steady driving conditions, many carburetors are designed to deliver the equivalent of a 6-to-1 air-fuel ratio immediately after the throttle is opened at low speeds. Other carburetors may be more effective in enriching the mixture at higher speeds than at extremely low speeds. But in practically all cases this characteristic is found to a greater or lesser degree.

A mixture ratio of 12 to 1 is required for maximum

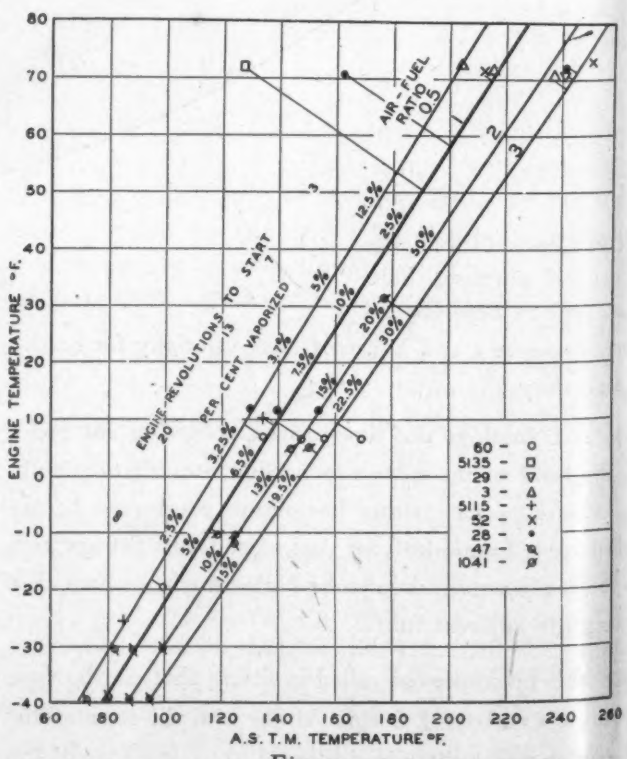


Figure 3

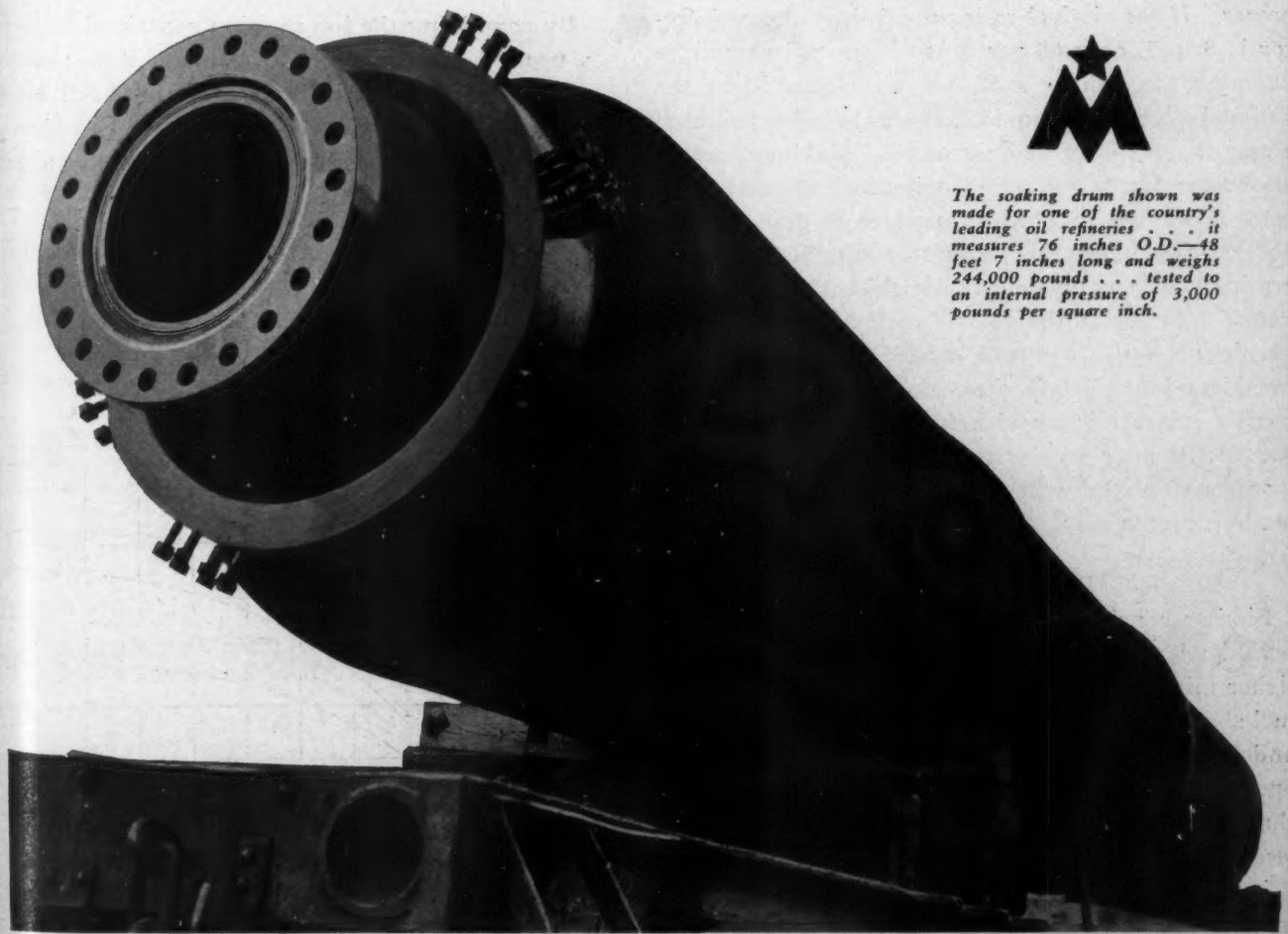
MIDVALE

MAKERS OF INTEGRALLY FORGED CRACKING CYLINDERS

The high pressure and high temperature operations encountered in present day refinery work require cracking vessels that assure the utmost in safety. The steel forged pressure cylinders made by The Midvale Company have stamina . . . they are built with an abnormal structural strength that permits them to withstand extremely high pressures with a wide margin of safety.

All Midvale cylinders are integrally forged from a single steel ingot . . . made without seams, welds, or rivets. A special Midvale forging operation is used to close in the ends of all vessels similar to the one shown below. This process makes the ends as solid as the walls thus assuring a uniform and homogeneous product.

Midvale is equipped to serve your metal needs, whether it is for large, small or medium sized work. Communicate with one of our offices located in Philadelphia, New York, Washington, Pittsburgh, Cleveland, Chicago and San Francisco and we will gladly help you with your problems.



The soaking drum shown was made for one of the country's leading oil refineries . . . it measures 76 inches O.D.—48 feet 7 inches long and weighs 244,000 pounds . . . tested to an internal pressure of 3,000 pounds per square inch.

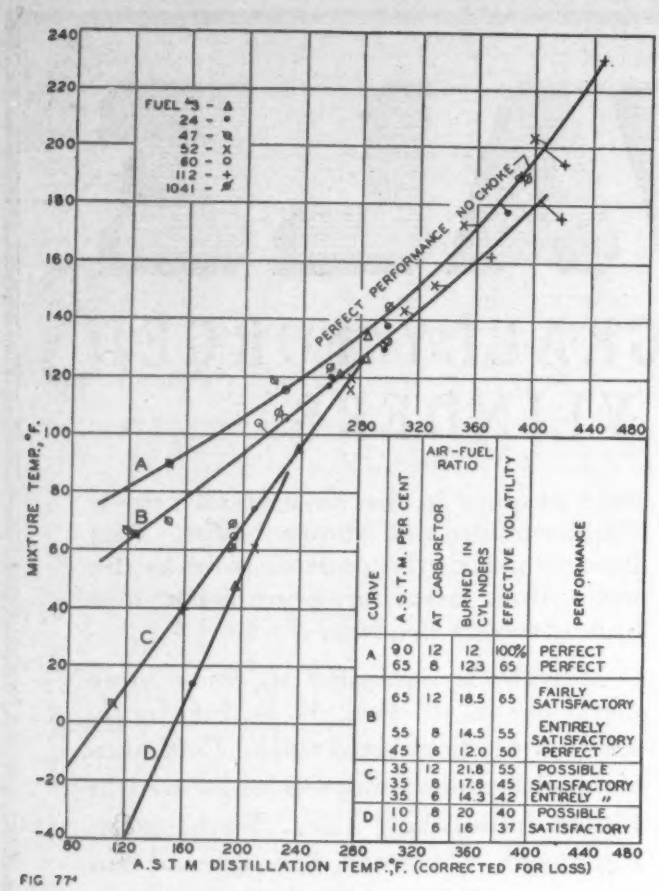


Figure 4

power. If the air-fuel ratio supplied by the carburetor is 8 to 1, only 66 per cent of the fuel should be vaporized to deliver a 12-to-1 air-fuel ratio at the cylinders even if no liquid fuel was being distributed along the walls of the manifold. Making a small allowance for the liquid distribution, about 65 per cent of the fuel should be vaporized to give the best acceleration when the carburetor supplies an accelerating charge equivalent to enriching the mixture to about 8 to 1. If the fuel is completely vaporized, an air-fuel ratio of 8 to 1 would be supplied to the cylinders immediately after the throttle is opened. Such a mixture is too rich for maximum power and causes the poor acceleration and loss in power frequently observed when using aviation gasoline in modern motor cars.

FUEL VAPORIZED

Similar considerations applied to the warming-up period when the choke is usually used to supply a richer mixture indicate that 35 to 40 per cent of the fuel should be vaporized for satisfactory performance under such conditions. It is usually possible to operate a motor with use of the choke on any fuel that will start the cold motor in 10 revolutions or less with a 1-to-1 air-fuel ratio. But with such a fuel it is usually necessary to continually work the choke in order to keep the motor running, while with 35 per cent of the fuel vaporized entirely satisfactory performance can usually be obtained at one position of the choke.

Figure 4 is presented as a summary of the data obtained on a number of different motors, and may be used with confidence provided only the mixture temperature as it enters the cylinder blocks, and the air-fuel ratio supplied by the carburetor are known with reasonable accuracy.

An extensive investigation into the metering characteristics of carburetors now in use, and the mixture temperature on different cars under atmospheric temperatures ranging from —20° to 90° F. may be summarized by the data presented in Figure 5. In this figure the mixture temperature as measured by a thermocouple in the intake manifold near the block is plotted as a function of time after the cold motor was started. The upper curves give the mixture temperature directly for modern motor cars equipped with radiator shutters and efficient manifold heating devices. The lower curves indicate the mixture temperature above atmospheric temperature for motors not equipped with thermostatically controlled radiator shutters. These temperatures vary with driving conditions and with the construction of the motor car. However, these two sets of curves in general may be taken as representing the two extreme types of motor equipment now in use.

By combining the information contained in Figure 3, 4 and 5, it is possible to estimate with sufficient accuracy for all practical purposes the A.S.T.M. distillation characteristics required in a fuel to give any desired quality of throttle response on the average

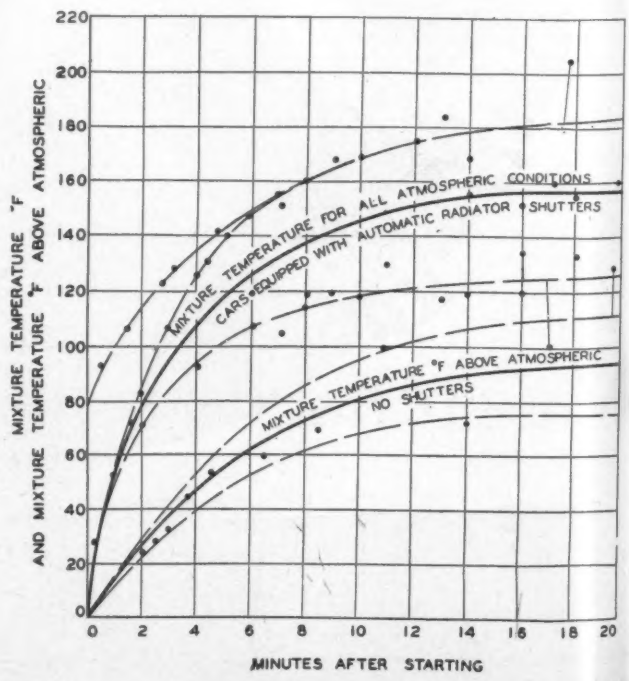
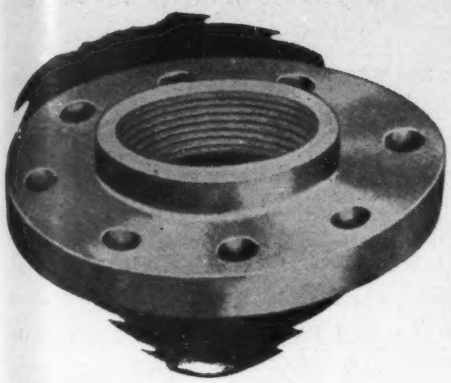

MIXTURE TEMPERATURE °F AND MIXTURE TEMPERATURE °F ABOVE ATMOSPHERIC
MIXTURE TEMPERATURE FOR ALL ATMOSPHERIC CONDITIONS
CARS EQUIPPED WITH AUTOMATIC RADIATOR SHUTTERS
MIXTURE TEMPERATURE °F ABOVE ATMOSPHERIC
NO SHUTTERS
MINUTES AFTER STARTING

Figure 5



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type of automotive equipment now in use. This has been done in preparing the two tables of suggested fuel volatility for different atmospheric temperatures given at the end of this paper.

VAPOR LOCK

Some cars heat the liquid fuel as well as the vapor to high temperatures and experience difficulty due to vapor lock when using fuels of high vapor pressure. The obvious remedy of this condition is proper design of the fuel system to keep the fuel at the lowest possible temperature until after it enters the intake manifold. But as long as such cars are on the road it is necessary that fuel be supplied to give satisfactory performance. Extensive road tests with cars susceptible to this trouble indicate that the probable maximum liquid fuel temperature may be represented by the following expression: Maximum fuel temperature °F. = 100 + ½ atmospheric temperature °F.

The tendency of a fuel to form vapor and cause trouble due to vapor lock is measured directly as its vapor pressure. In the complete report relationships between vapor pressure as determined in the Reid bomb and probable vapor locking temperature are given. For the present the temperature at which the 10 per cent is vaporized in the A.S.T.M. distillation may be taken as a fair approximation of the temperature at which the vapor pressure of the fuel is equal to atmospheric pressure. For this reason the safe minimum 10 per cent temperature in °F. may be taken as:

$$\frac{100 + \text{average atmospheric temp.}}{2}$$

TABLE 1—THE RELATION BETWEEN A.S.T.M. DISTILLATION AND MOTOR PERFORMANCE AT DIFFERENT ATMOSPHERIC TEMPERATURES

For modern motor cars equipped with exhaust-heated manifold hot spot, carburetor with effective accelerating device, and radiator shutters.

	——Points on A.S.T.M. distillation with loss added at lower end——							
	——10%——		——35%——		——60%——		——90%——	
Atmos. temp. °F.	Minimum °F.	Maximum °F.	½ minute °F.	2 minutes °F.	4 minutes °F.	8-10 minutes °F.	Minimum °F.	Maximum °F.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
80	140	230	235	275	275	320	390	450
50	125	190	200	250	260	310	375	420
20	110	150	175	230	235	290	350	400
—10	90	100	125	210	180	280	320	400

Column (1)—Average atmospheric temperature in which the cold motor is started and operated.

Column (2)—The lowest 10 per cent temperature consistent with easy starting of cold motor, and freedom from vapor-lock with hot motor.

Column (3)—The highest 10 per cent temperature which allows starting and warming up without difficulty under average conditions.

Column (4)—The maximum 35 per cent temperature which allows possible to fairly satisfactory operation without choking about one-half minute after starting, or entirely satisfactory performance with the use of the choke.

Column (5)—The maximum 35 per cent temperature which allows similar operation about 2 minutes after starting.

Column (6)—The maximum 60 per cent temperature giving almost perfect performance without choking about 4 minutes after starting.

Column (7)—The maximum 60 per cent temperature giving perfect performance without choking about 8 to 10 minutes after starting.

Column (8)—The minimum 90 per cent temperature not causing loss in acceleration on warm motor.

Column (9)—Maximum temperatures of 90 per cent now known to be satisfactory under indicated conditions.

TABLE 2

For cars not equipped with radiator shutters, and supplying less heat to the intake manifold, or with carburetor which supplies only a limited accelerating charge.

	——10%——		——35%——		—65%—	——90%——	
Atmos. temp. °F.	Minimum °F.	Maximum °F.	½ minute °F.	4 minutes °F.	8-10 minutes °F.	Minimum °F.	Maximum °F.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
80	135	230	235	280	300	320	450
50	115	190	190	240	260	250	410
20	100	150	150	200	200	180	390
—10	85	100	100	160	120	120	370

Column (1)—Average atmospheric temperature in which the cold motor is started and operated.

Column (2)—The lowest 10 per cent temperature consistent with easy starting of cold motor, and freedom from vapor-lock with hot motor.

Column (3)—The highest 10 per cent temperature which allows starting and warming up without difficulty under average conditions.

Column (4)—The maximum 35 per cent temperature which allows possible to fairly satisfactory operation without choking about one-half minute after starting or entirely satisfactory performance with the use of the choke.

Column (5)—The maximum 35 per cent temperature which allows similar operation about 4 minutes after starting.

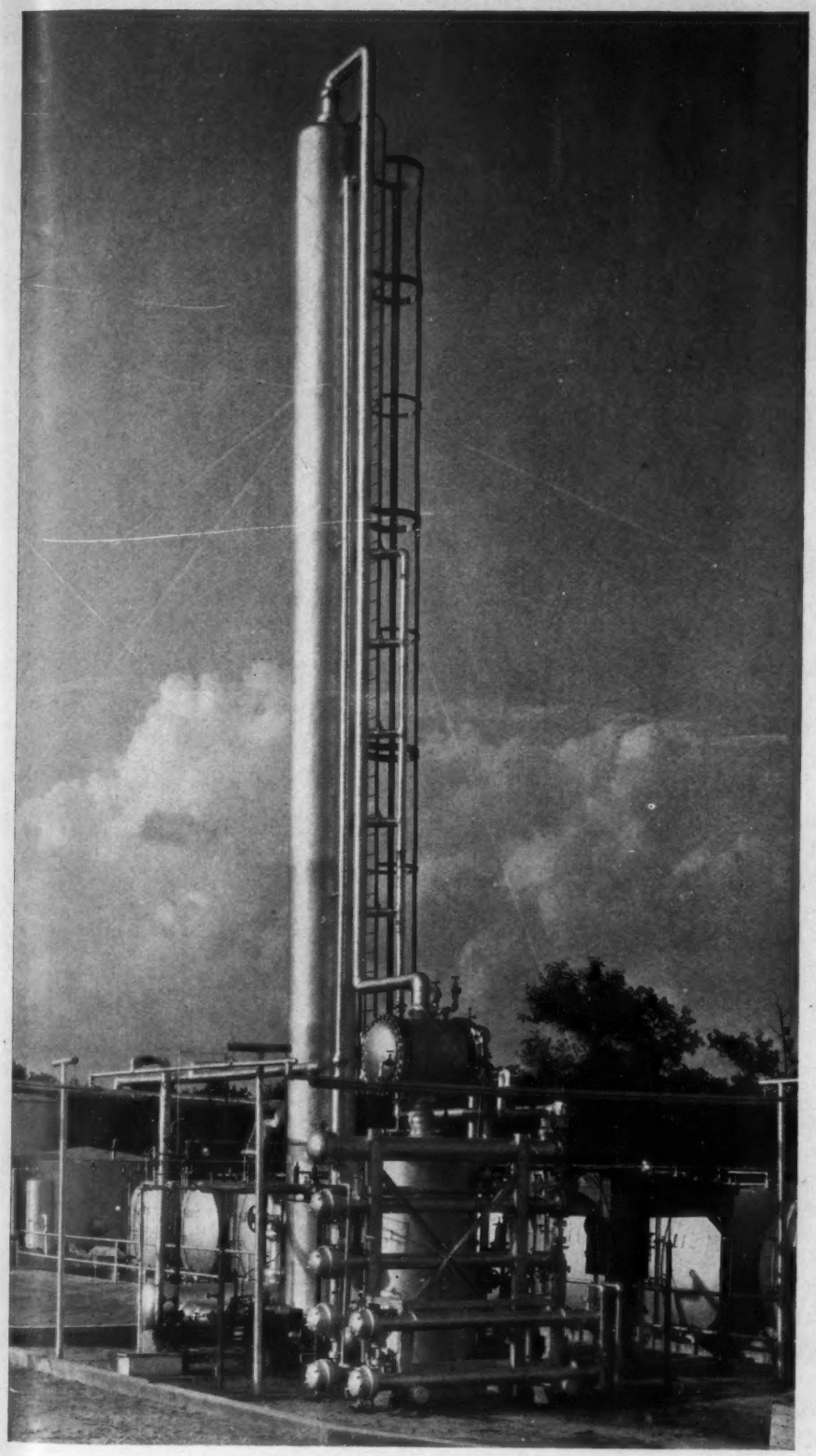
Column (6)—The maximum 65 per cent temperature giving perfect performance without choking about 8 to 10 minutes after starting.

Column (7)—The minimum 90 per cent temperature not causing loss in acceleration on warm motor.

Column (8)—Maximum temperatures of 90 per cent now known to be satisfactory under indicated conditions.

A.S.T.M. DISTILLATION CHARACTERISTICS IN TERMS OF ENGINE PERFORMANCE

The differences in the fuel requirements of different motors are due largely to differences in mixture temperature and in carburetor metering characteristics rather than in the distributing characteristics of the manifold. For this reason data such as suggested in the accompanying tables may be readily computed by anyone from a knowledge of the air-fuel ratio supplied by the carburetor, the mixture temperature entering the engine block, and the chart given in Figures 3 and 4.



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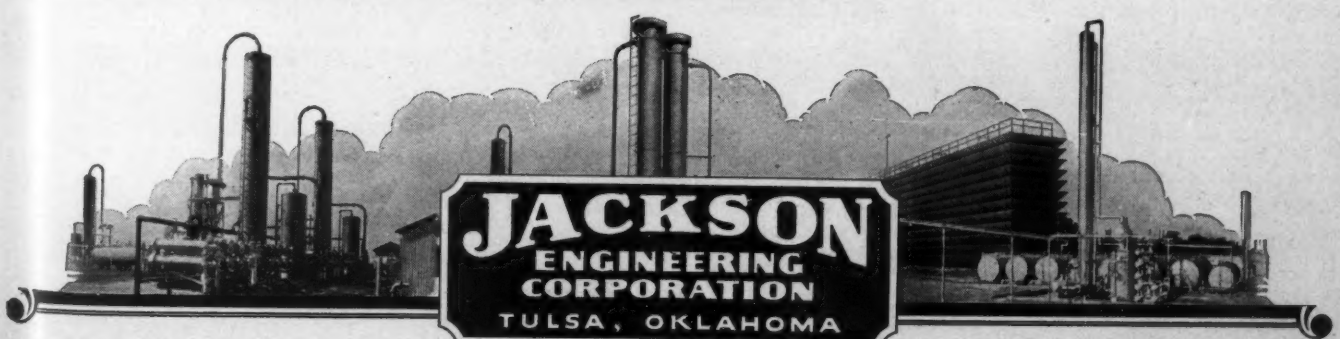

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Theoretical Analysis the Key to Absorption Plant Design

By ALOIS KREMSER
Standard Gasoline Company

Proceedings of Natural Gasoline Association

IT is the purpose of this paper to present a mathematical analysis of the relations underlying the oil absorption process, especially as applied to the extraction of gasoline from natural gas. General equations are derived for evaluating the effect of important variables, such as pressure, temperature, oil rate, number of plates, plate efficiency, richness and composition of gas, physical properties of absorption oil, etc., on the performance of absorbers and on the efficiency of extraction.

To simplify the mathematical analysis, the assumption is made that pressure, oil, rate, gas rate, and temperature are constant throughout the absorber. This condition is approximated in average field practice, especially if efficient extraction of butanes is attempted. The assumption is not fulfilled with gases of abnormal richness such as refinery vapors or with high pressure plants in which a high saturation of the oil is obtained. In such cases it will be necessary to apply the theory to the conditions as they obtain both at the top and bottom of the absorber and to estimate probable results from the data thus computed.

Absorption is essentially a vapor pressure phenomenon. The driving force is the difference between the partial pressure of a constituent in the gas and the vapor pressure due to the portion absorbed in the liquid. If this difference is zero, no further absorption is possible; in other words, equilibrium has been reached. The mathematical treatment is based on the assumption that Raoult's law may be applied. This is another limitation of the analysis.

It will be shown that computations based on the total gasoline content of gas, without regard to its composition, must, by necessity, be misleading. The absorption of each constituent, such as butane, pentane, etc., is practically independent of the others. The absorption of each constituent of the gas will, therefore, be treated individually.

The theory presented here has been a valuable aid in our operation, as a basis for evaluating test data for plant control and design of new plants. Experience with over 40 plants covering practically all the variations encountered in normal practice has indicated that the assumptions outlined above do not detract seriously from the usefulness of the theory for all practical purposes.

PART 1—DERIVATION OF EQUATIONS

1. Nomenclature

P Absorber pressure, pounds per square inch absolute.

p Vapor pressure of gasoline fraction at a given temperature, pounds per square inch absolute.

G Oil to gas ratio, gallons per 1000 standard cubic feet (measured at 60° F. and 14.7 pounds per square inch absolute.

y Gasoline content of gas, gallons per 1000 standard cubic feet.

x Saturation of oil, per cent gasoline by volume.

q Equilibrium constant, defining the equilibrium between x and y; $x = qy$.

s Saturation of oil, expressed in mol per cent.

r Ratio of mol percentage to volume percentage.

v Standard cubic feet of vapor per gallon of gasoline.

M Molecular weight of absorption oil (sponge.)

m Molecular weight of gasoline fraction.

D Specific gravity of sponge.

d Specific gravity of gasoline fraction.

t Temperature ° F.

n Number of plate, plate n+1 is below plate n.

A Absorption factor $A = \frac{Gq}{100}$.

2. Equilibrium Relations

(a) Relation Between Mol Percentage and Volume Percentage.—The vapor pressure of the solute is proportional to the molecular percentage. As it is customary to use volume percentages in plant practice, a simple relation between the two is desirable:

Given: M and m, molecular weight of sponge and gasoline fraction.

D and d, specific gravity of sponge and gasoline fraction.

$100 - x$ and x, volume percentages.

The number of mols will be proportionate to:

$$\frac{xd}{m} \text{ and } \frac{(100-x)D}{M}$$

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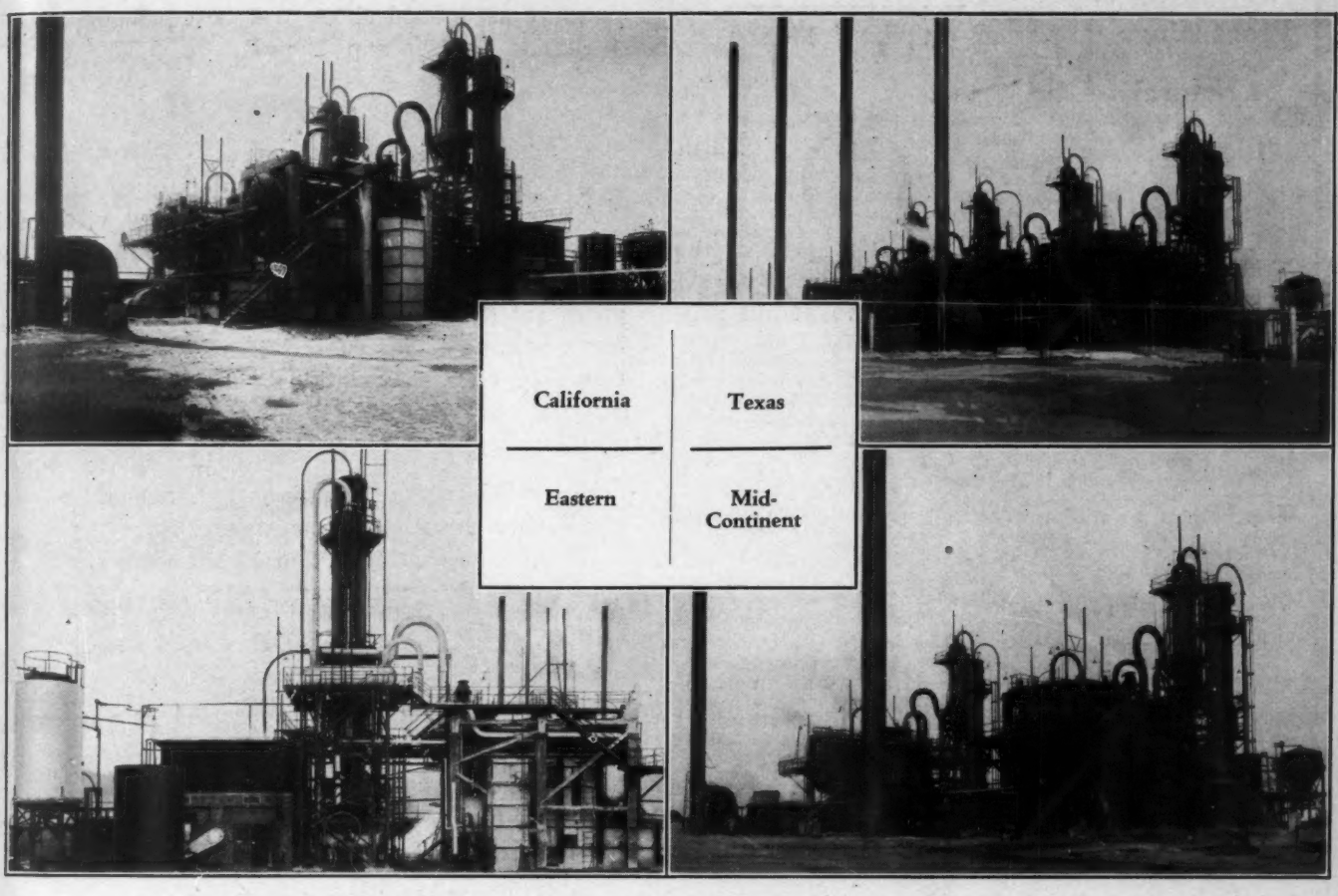

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The mol percentages will, therefore, be:

$$s = \frac{100\,\frac{xd}{m}}{\frac{xd}{m} + \frac{(100-x)D}{M}} \qquad (1)$$

$$s = \frac{100x}{x\left(1 - \frac{Dm}{dM}\right) + \frac{Dm}{dM}100}$$

In absorption practice the saturation is generally sufficiently low to permit neglecting the first term in the denominator. Equation 1 can, therefore, be simplified to:

$$s = x\frac{dM}{Dm} \qquad (2)$$

The ratio r of mol percentage to volume percentage is, therefore:

$$r = \frac{dM}{Dm} \qquad (3)$$

(b) Equilibrium Equation.—If a gas at an absolute pressure P contains y gallons per 1000 standard cubic feet of a gasoline fraction having v cubic feet of vapor per gallon of liquid, the partial pressure of the vapor will be:

$$\text{Partial pressure} = \frac{yvP}{1000} \text{ lbs. per sq. in.}$$

If the absorption oil contains x volume per cent of a gasoline fraction, which has at a given temperature a vapor pressure p and a mol-vol. per cent ratio, r, the vapor pressure of the absorbed gasoline will be:

$$\text{Vapor pressure} = \frac{rxp}{100} \text{ lbs. per sq. in.}$$

For equilibrium the partial pressure and vapor pressure as defined above will be equal, or

$$\frac{rxp}{100} = \frac{yvP}{1000}$$

$$x = \frac{vP}{10rp} \quad y = qy \qquad (4)$$

A general relation may be derived for v, the volume of vapor per gallon, from the fact that 1 gallon weighs 8.33d pounds, and that the pound mol of all gases (at 60° F. and 14.7 pounds per square inch) has a volume of 379 cubic feet, v may be computed, therefore, from the relation:

$$v = \frac{8.33d\,379}{m} = 3156\frac{d}{m} \qquad (5)$$

By combining the equations (3), (4) and (5) the equilibrium equation assumes the form:

$$x = \frac{3156d\,PDm}{m\,10dMp}\,y = qy, \text{ and}$$

$$q = \frac{315.6\,DP}{Mp} \qquad (6)$$

"q" may be defined as the equilibrium constant. It is a function of absorber pressure, vapor pressure of gasoline fraction and physical properties of sponge, but independent of all other variables involved in the absorption process.

3. Analysis of Single Plate

The n^{th} plate shall be considered. Oil from the plate above will enter it with a saturation x_{n-1}, gas from the plate below with a gasoline content y_{n+1}. Oil and gas will approach on the n^{th} plate an equilibrium, depending on temperature and pressure conditions, defined by equation (4), namely:

$$x_n = q\,y_n$$

The oil rate is assumed as G gallons per 1000 cubic feet, G gallons of oil entering with saturation x_{n-1} and leaving with x_n will take up:

$$\frac{G}{100}(x_n - x_{n-1}) \text{ gallons of gasoline.}$$

1,000 cubic feet of gas entering with gasoline content y_{n+1} leaving with v_n give up

$y_{n+1} - y_n$ gallons of gasoline.

The two quantities must be equal, also the equilibrium (4) may be applied as follows:

$$\frac{G}{100}(x_n - x_{n-1}) = y_{n+1} - y_n$$

$$x_n = q\,v_n \text{ and } x_{n-1} = q\,y_{n-1}$$

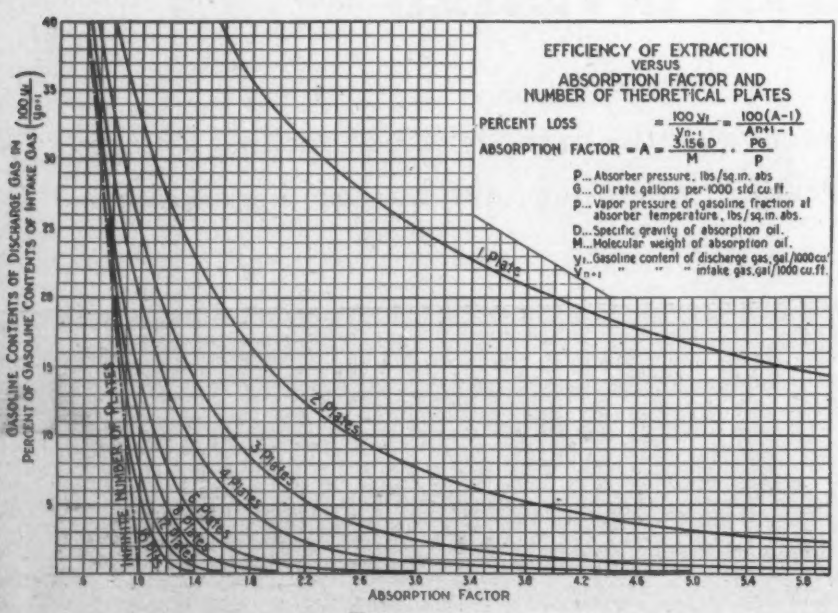
EFFICIENCY OF EXTRACTION
VERSUS
ABSORPTION FACTOR AND
NUMBER OF THEORETICAL PLATES
PERCENT LOSS = 100 y1 / yn+1 = 100(A-1) / A^(n+1) - 1
ABSORPTION FACTOR = A = 3.156 D / M . PG / p
P... Absorber pressure, lbs/sq.in. abs
G... Oil rate gallons per 1000 std cu ft
p... Vapor pressure of gasoline fraction at absorber temperature, lbs/sq.in. abs.
D... Specific gravity of absorption oil.
M... Molecular weight of absorption oil.
y1.. Gasoline content of discharge gas, gal/1000 cu ft
yn+1 " " " intake gas, gal/1000 cu ft
1 Plate
2 Plates
3 Plates
4 Plates
5 Plates
6 Plates
INFINITE NUMBER OF PLATES
GASOLINE CONTENTS OF DISCHARGE GAS IN PERCENT OF GASOLINE CONTENTS OF INTAKE GAS (100 y1 / yn+1)
ABSORPTION FACTOR

Diagram 1

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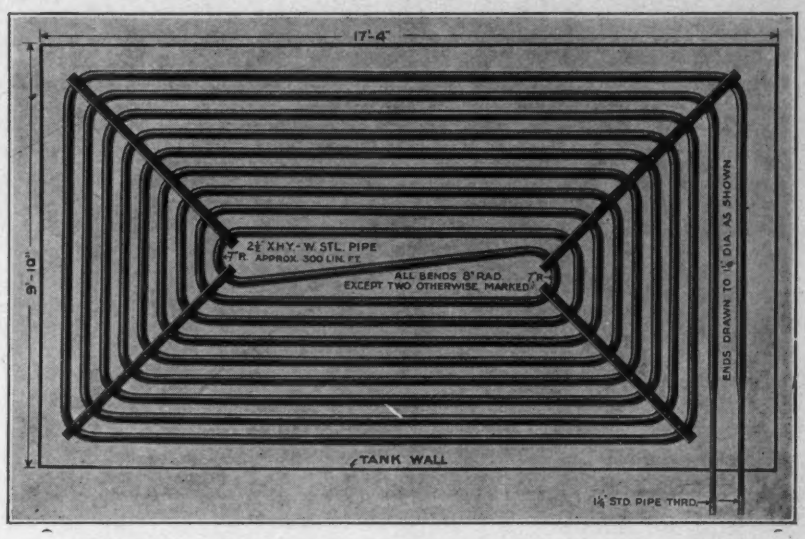

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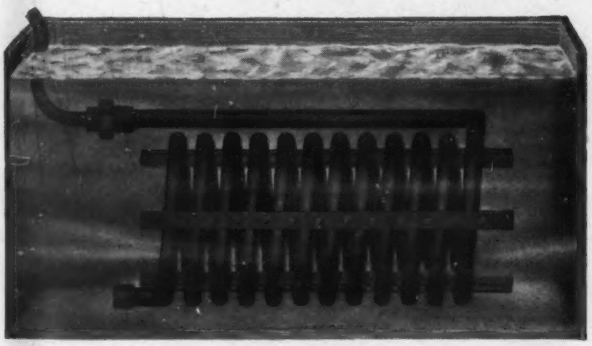

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These equations may be combined, as follows:

$$\frac{Gq}{100}(y_n - y_{n-1}) = y_{n+1} - y_n \qquad (7)$$

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The term $\frac{Gq}{100}$ shall be defined by the symbol A and designated as absorption factor

$$A = \frac{Gq}{100} \qquad (8)$$

Equation (7) can be solved for y_n, giving the important relation

$$y_n = \frac{y_{n+1} + A\,y_{n-1}}{1 + A} \qquad (9)$$

4. Absorption Factor

It is evident from the above derivation that the performance of an absorber may be defined in terms of a single factor designated as absorption factor. By combining equations (6) and (8) it may be expressed by the relation:

$$A = \frac{3.156\ DPG}{Mp} \qquad (10)$$

It will be noted that the absorption factor is directly proportional to absorber pressure and oil rate, and inversely proportional to the molecular weight of the absorption oil and the vapor pressure of the individual gasoline fractions, which, in turn, are defined by temperature.

According to this derivation, the absorption factor defines completely the absorption phenomenon; in other words, it is immaterial under what conditions the absorption process is carried out as long as the value of the absorption factor remains constant.

5. The Multiple Plate Absorber

(a) Single-Plate Absorber.—By applying equation (9) to a single plate it may be written:

$$y_1 = \frac{y_2 + Ay_0}{1 + A} \qquad (11)$$

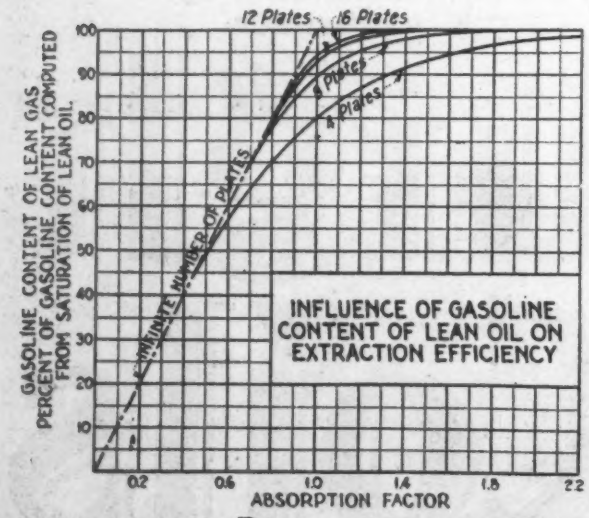

12 Plates
16 Plates
8 Plates
4 Plates
2 Plates
INFINITE NUMBER OF PLATES
GASOLINE CONTENT OF LEAN GAS
PERCENT OF GASOLINE CONTENT COMPUTED FROM SATURATION OF LEAN OIL
INFLUENCE OF GASOLINE CONTENT OF LEAN OIL ON EXTRACTION EFFICIENCY
ABSORPTION FACTOR

Diagram 2

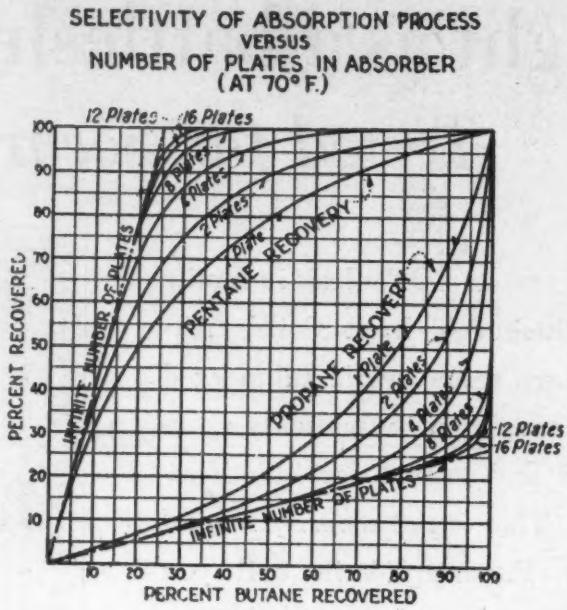


Diagram 3

y_2 is evidently the gasoline content of the gas entering the plate and, therefore, the absorber. y_0 is the gasoline content of a gas in equilibrium with the known saturation x_0 of the oil entering the absorber and may be computed from the latter by the relation $x_0 = qy_0$.

(b) Two-Plate Absorber.—The gasoline content of the gas leaving the bottom plate may be computed from equation (9):

$$y_2 = \frac{y_3 + Ay_1}{1 + A} \qquad (12)$$

By introducing y_1 from equation (11) and solving for y_2, the following relation is obtained:

$$y_2 = \frac{(A+1)y_3 + A^2y_0}{A^2 + A + 1} \qquad (13)$$

(c) Three-Plate Absorber.—By applying equation (9) to y_3 and substituting equation (13) for y_2 and solving for y_3, the latter may be expressed as:

$$y_3 = \frac{y_4(A^2 + A + A^3y_0}{A^3 + A^2 + A + 1} \qquad (14)$$

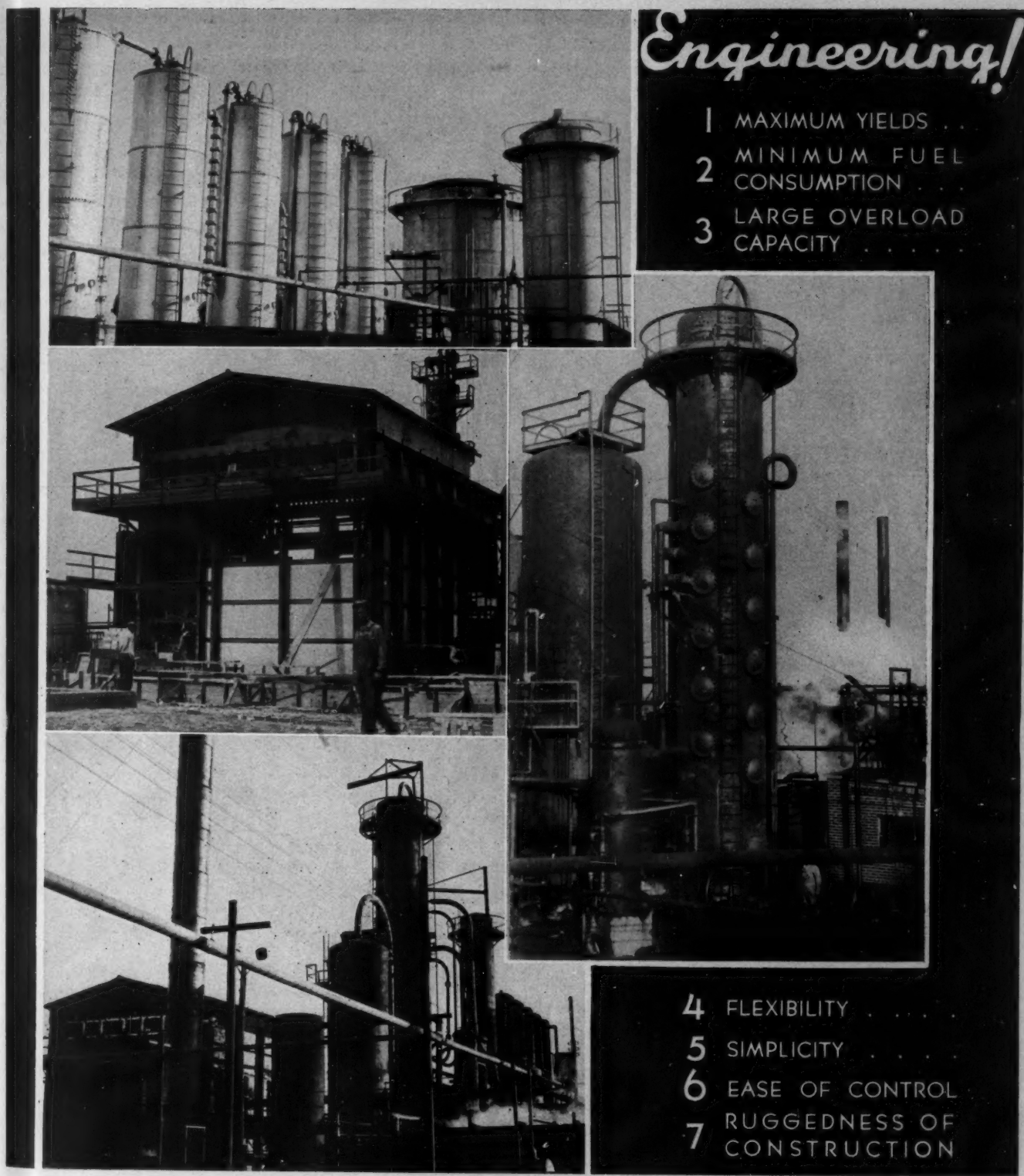
This may also be written in the form:

$$y_3 = \frac{\frac{A^3 - 1}{A - 1}y_4 + A^3y_0}{\frac{A^4 - 1}{A - 1}} = \frac{(A^3 - 1)y_4 + A^3(A - 1)y_0}{A^4 - 1} \qquad (15)$$

(d) n-Plate Absorber.—Equation (15) for the three-plate absorber indicates the form of the general equation. It may be written:

$$y_n = \frac{y_{n+1}(A^n - 1) + (A - 1)\,A^n y_0}{A^{n+1} - 1} \qquad (16)$$

The gasoline content y_n of the gas leaving the bot-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tom plate is of little interest. But the saturation x_n of the oil leaving the absorber may be computed from equation (16) and the relation $x_n = qy_n$.

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Of special interest is the gasoline content of the gas leaving the absorber, or in our nomenclature y_1.

The gasoline extracted by G is: $\frac{G(x_n - x_0)}{100}$, the gasoline given up by 1,000 cubic feet, and equals $y_{n+1} - y_1$. Therefore:

$$\frac{G(x_n - x_0)}{100} = y_{n+1} - y_1, \text{ or introducing}$$

$$x_n = q\,y_n;\ x_0 = q\,y_0;\ \text{and } \frac{Gq}{100} = A$$

$$A(y_n - y_0) = y_{n+1} - y_1 \qquad (17)$$

Combining (16) and (17), there results the important equation:

$$y_1 = \frac{(A-1)}{A^{n+1}-1}\,y_{n+1} + \frac{A(A^n-1)}{A^{n+1}-1}\,y_n \qquad (18)$$

y_{n+1} is the gasoline content of the gas entering the absorber.

$y_0 = \frac{x_0}{q}$ can be computed from the saturation x_0 of the lean oil entering the absorber. The absorption factor A has been discussed above. Equation (18) represents, therefore, a general solution of the absorption problem, by which all factors entering the problem may be evaluated.

It will be noted that the first term in equation (18) is only a function of the richness of the gas entering the absorber, of the absorption factor and of the number of plates. It represents the limit to which the gasoline content of the gas could be reduced if the oil entering the absorber were perfectly stripped, that is, would contain no gasoline fractions. The second term defines the limitations imposed on absorption efficiency by the gasoline content of the lean sponge, that is, of the oil entering the absorber. The two terms are entirely independent of each other, except that their sum represents the gasoline content of the gas leaving the absorber.

6. Equilibrium and Transfer Theory

The analysis so far has been based on equilibria only without any regard to the mechanism by which equilibrium is established. Actually the transfer of gasoline fractions from vapor to liquid will depend: on the driving potential, that is, the difference between the partial pressure in the vapor phase and the vapor pressure in the liquid phase; the contact area between liquid and vapor, be it in the form of grids or similar contact devices, or in the form of bubbles, as in plate absorbers; the time of contact; and the transfer coefficient, that is, the amount transferred per unit of area in unit time per unit of driving potential.

The absorber may be assumed as subdivided into a number of equal units, each representing a theoretical plate. The transfer surface and time of contact available in each unit will be substantially constant, especially for the problem discussed, in which the flow rates of both liquid and gas are essentially constant throughout the absorber.

The transfer factor is primarily a function of the physical properties of the substances involved and of velocity. It will, therefore, be substantially constant throughout the absorber.

Under these conditions an analysis based on equilibria will be justified only if it can be shown that the amount transferred on each theoretical plate is proportionate to the driving potential on each plate.

This condition is fulfilled, as shown by the following analysis of the n^{th} plate:

Qn Amount transferred on n^{th} plate.

Fn Initial driving potential on n^{th} plate.

Gas enters and leaves the n^{th} plate with a richness y_{n+1} and y_n. The amount transferred is therefore:

$$Qn = y_{n+1} - y_n \qquad (19)$$

By substituting equation (9) for y_n, (19) may be written:

$$Qn = \frac{A}{1+A}(y_{n+1} - y_{n-1}) \qquad (20)$$

The partial pressure of the entering gas is $y_{n+1}\frac{vP}{1000}$. The vapor pressure of the sponge, coming from plate n — 1, with saturation x_{n-1}, is $x_{n-1}\frac{pr}{100}$. The initial driving potential is therefore:

$$Fn = y_{n+1}\frac{vp}{1000} - x_{n-1}\frac{pr}{100} \qquad (21)$$

According to equation (4), the second term in equation (21) may be written:

$$x_{n-1}\frac{pr}{100} = \frac{vP}{1000}y_{n-1}$$

Equation (21) therefore assumes the form:

$$Fn = \frac{vP}{1000}(y_{n+1} - y_{n-1}) \qquad (22)$$

Equations (20) and (22) may be combined as follows:

$$\frac{Qn}{Fn} = \frac{1000A}{vP(1+A)} = \text{constant} \qquad (23)$$

It is found that the amount of gasoline transferred

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on each theoretical plate is directly proportional to the initial driving potential, although the analysis is based on equilibria only. Without discussing these relations in further detail, the conclusion appears justified that under these conditions the final results would be substantially the same, whether the absorption phenomenon is analyzed from the viewpoint of the transfer or from that of the equilibrium theory.

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PART 2—APPLICATION TO PLANT PRACTICE

The mathematical relations established in the first part of the paper permit a quantitative evaluation of every important variable entering the absorption problem. One of the most important variables, it has been shown, is the absorption factor. Since the value of the latter depends on the vapor pressure of the individual gasoline constituents it will be evident that with other conditions such as pressure, oil rate, etc., constant, the absorption factor for butane will be much lower than that of pentane; in other words, the absorption of every gasoline constituent will have to be treated individually. In general, it will be desirable, however, that extraction of the heavier constituents beginning with iso-pentane be as complete as possible. Butane extraction will be more or less complete, depending on the quality of natural gasoline desired. The size of plant and general operating conditions will be determined, therefore, primarily by the requirements as regards butane extraction. The absorption factor for butane, or briefly the butane factor, will, therefore, be of special significance. For that reason it will be desirable to use the butane factor as a basis for the general analysis of the problem, and to define the conditions, which will insure any desired extraction efficiency for other constituents in terms of the butane factor.

1. Relations Between Gasoline Content, Absorption Factor and Number of Plates.—In the ideal case, that is, if the oil entering the absorber is free of gasoline constituents, the second term in equation (18) is zero. It may be written, therefore, in the form:

$$\frac{100\ y_1}{y_{n+1}} = \frac{100\ (A-1)}{A^{n+1}-1} \qquad (24)$$

y_1 and y_{n+1} are the gasoline content of the gas leaving and entering the absorber, or equation (24) gives the gasoline content of the discharge gas, expressed as a percentage of the gasoline content of the gas entering the absorber.

For the purpose of further discussion it will be more convenient to present the relations defined by equation (24) in graphical form, as shown in Diagram 1.

(a) Number of Plates.—The diagram illustrates strikingly the importance of an adequate number of plates for efficient extraction. To reduce, for instance, the richness of the discharge gas in any individual gasoline constituent to 1 per cent of that of the intake gas, the following absorption factors would be required with different numbers of plates:

Number of theoretical plates	3	4	6	8	12	16	infinite
Absorption factor	4.2	2.8	1.9	1.56	1.3	1.2	0.99

As the required oil rate and absorber pressure are directly proportional to the absorption factor, it is evident that large savings in plant equipment will result if an adequate number of plates are provided in the absorber. The saving will be very marked up to about 12 theoretical plates, but will be less pronounced from then on. For instance, the reduction in oil rate between 8 and 12 plates is about the same as between 16 and an infinite number of plates. The economical number of theoretical plates will, therefore, lie between rather definite limits. The statement appears justified that it should not be less than 12 plates, but that the gain from increasing it beyond 16 plates will be relatively insignificant.

If less efficient extraction is desired, the number of plates is of less significance. For instance, if 20 per cent of any individual constituent may be rejected, the absorption factors for six, eight and an infinite number of plates would be 0.88, 0.84 and 0.8, respectively; in other words, little would be gained by going beyond six theoretical plates. This conclusion is of practical interest only in specific instances, discussed later. For general practice it will be preferable to install a number of plates which will permit efficient extraction without the necessity of using abnormally high absorption factors, that is, oil rates or absorber pressures.

(b) Plate Efficiency.—The number of actual plates required, for instance in a bubble plate absorber, will depend on the plate efficiency. An important problem in that connection will be the relation between plate efficiency and number of plates, that is, whether it is more economical to use a smaller number of plates of high efficiency and, therefore, elaborate design or a larger number of plates of relatively low efficiency. Diagram 1 permits of a convenient analysis of this problem. Assuming a 16-plate absorber with 62.5 per cent plate efficiency its performance will be equivalent to an absorber having 10 theoretical plates. It will be evident that a 12-plate absorber would have to have an efficiency of 83.5 per cent to give the same extraction, and that an eight-plate absorber, no matter how high its efficiency, could not give the same performance. The effect on extraction can be estimated as follows:

Number of actual plates	...	20	16	12	8
Assumed plate efficiency	...	62.5	62.5	83.5	100
Theoretical plates	...	12.5	10	10	8
Per cent lost for abs. factor	1.2	1.9	3.1	3.1	4.8
Per cent lost for abs. factor	0.8	21.0	21.9	21.9	23.1

These simple examples are considered sufficient to

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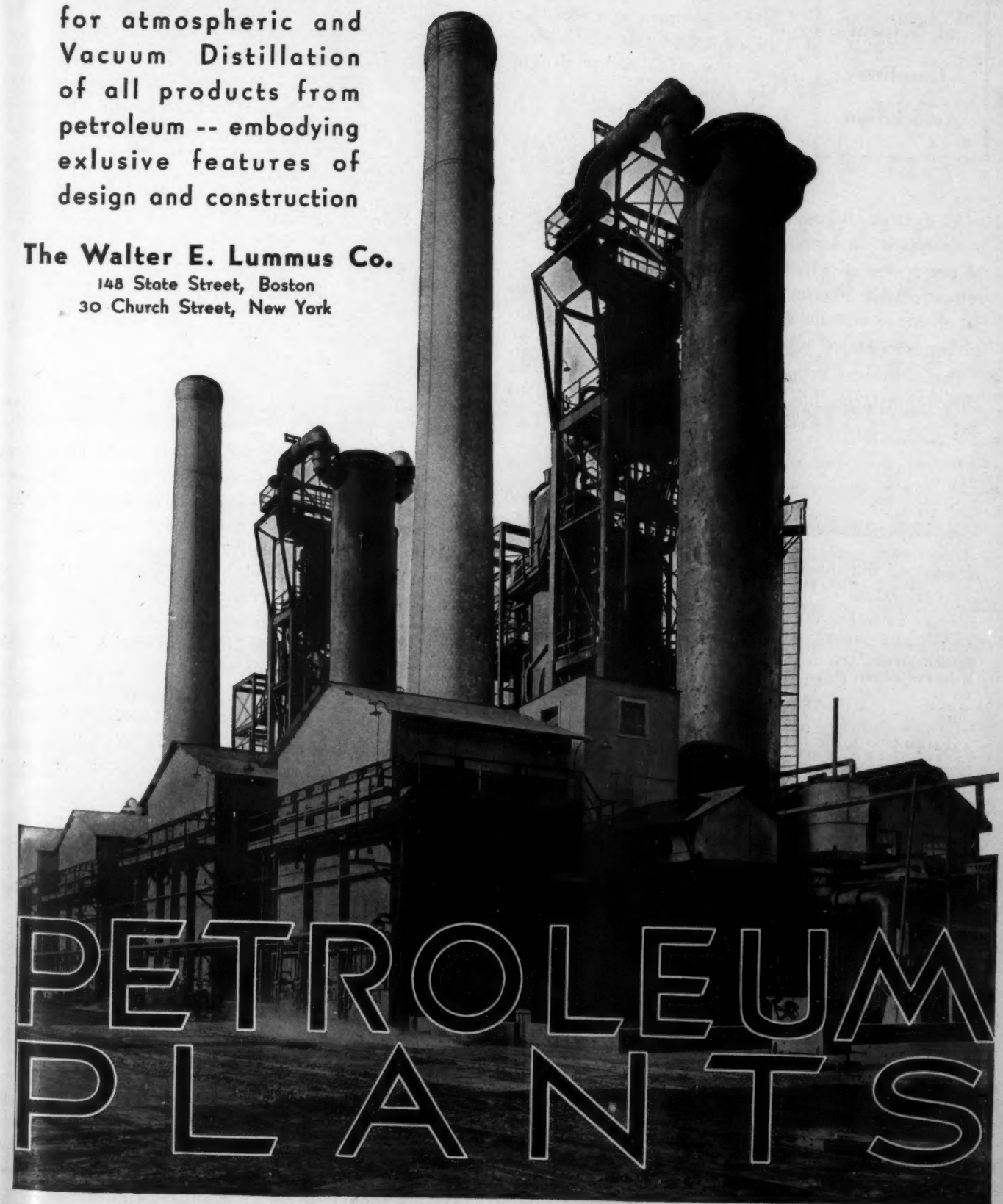

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justify the statement that a 16-plate absorber of moderate plate efficiency will in general give a better performance than more elaborate absorbers having a lower number of plates. For that reason and because of the difficulty in actually determining the plate efficiency, it will be to the advantage of the plant operator to insist on a minimum of 16 plates irrespective of absorber design. In exceptional cases, where complete extraction of butanes is desired, it may be economical to use even a larger number of plates.

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All further discussion will be based, therefore, on a "standard" absorber, assumed to have 16 plates of 75 per cent plate efficiency, or equivalent to 12 theoretical plates. Extraction of any constituent in such an absorber will be 99 per cent complete if the absorber is operated with an absorption factor of 1.30.

(c) Physical Properties of Absorption Oil.—The absorption factor has been defined by equation (10) as:

$$A = 3.156 \frac{D}{M} \frac{PG}{p}$$

This formula contains the ratio $\frac{D}{M}$, that is, the density of the absorption oil to its molecular weight. Typical values of this ratio for oils of different gravity are as follows:

A.P.I. gravity of absorption oil	32°	34°	36°	38°	40°
Specific gravity, D 0.865	0.855	0.845	0.835	0.825	
Molecular weight, M 192	182	173	164	155	
$\frac{100\ D}{M}$ 0.450	0.466	0.488	0.508	0.532	

From this table it will be apparent that the absorbtion factor is increased approximately 2 per cent for every 1° increase of gravity. The lighter oil will lend itself also to better atomization in the absorber, an effect which will tend to increase the apparent plate efficiency of the absorber.

It will be to advantage, therefore, to use a relatively light oil. It must be remembered, however, that stripping is a phenomenon opposite to that of absorption. The lighter the oil the more difficult it will be to strip it, the more efficient will have to be the stripping equipment, and the higher will, other things equal, be the steam consumption. Only plants equipped with modern stripping equipment will, therefore, derive any benefit from light oil. Other plants will use to advantage a heavier oil, because it is possible to compensate for its lower absorption efficiency by an increased oil rate, while no remedy can be had against losses due to imperfect stripping of the lean oil.

By introducing the $\frac{D}{M}$ — the value corresponding to a 38° gravity oil, the formula for the absorption is reduced to the simple form:

$$A = 0.016 \frac{PG}{p} \qquad (25)$$

(d) Effect of Temperature.—The absorption factor depends on the vapor pressure of the gasoline constituents. The effect of temperature can be illustrated, therefore, by tabulating the vapor pressures of isopentane and normal butane for the operating range, that is, between 60° F. and 100° F.

The vapor pressure of isopentane increases approximately 21 per cent, that of normal butane about 19 per cent for every 10° rise of temperature. Since the absorption factor is inversely proportionate to vapor pressure, it follows that the absorption factor is decreased 2 per cent by every 1° rise of temperature. This is a very important statement. There are probably many plants in which the lean oil temperature could be reduced at least 10° F. by more adequate cooling facilities. The result would be a 20 per cent increase of absorption factor with a corresponding increase of extraction efficiency. If the extraction is adequate, the oil rate could be reduced 20 per cent with a corresponding reduction of load on pumps, heat exchangers, stills, boilers, condensers, etc., and, therefore, ultimate load on cooling towers. There is hardly any simple improvement in plant operation which has such a beneficial effect on the whole plant performance as a relatively small decrease in the temperature of the absorption oil. Proper design maintenance and operation of the cooling towers deserves, therefore, the most careful attention. It is one of the most effective methods of providing additional capacity in overloaded plants.

(e) Effect of Oil Rate and Absorber Pressure.—The absorption factor is directly proportional to both oil rate, expressed in gallons per 1,000 cubic feet, and to the absolute absorber pressure. The same absorption factor can be obtained, therefore, by any desired combination of pressure and oil rate. By doubling the pressure, the oil rate may be cut into half, etc.

This statement is not exactly true. If the absorption factor is doubled by increase of pressure alone, the oil rate would cause a corresponding increase of temperature at the bottom of the absorber, which in turn would cause a slight decrease of absorption factor as discussed above.

On the other hand, doubling the absorption factor by maintaining the pressure, but doubling the oil rate, would have the opposite effect on temperature and therefore give a somewhat higher absorption factor than indicated by direct proportions.

It should be remembered, therefore, that allow-

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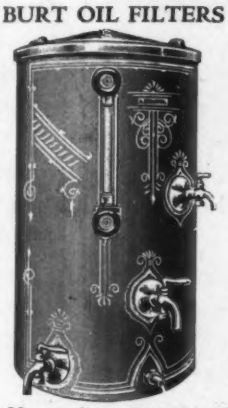

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ance must be made for the effect of temperature on the absorption factor, if changes in pressure or oil rate affect the saturation and, therefore, indirectly the absorber temperature. With high pressure plants or very rich gases it may be economical to resort to intercooling of the oil in the absorber to obtain the full benefit of the pressure and oil rate maintained in the plant; in other words, to counteract large decrease of absorption factor caused by an abnormal temperature rise in the absorber.

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(f) The Absorption of Different Gasoline Constituents.—The absorption of each gasoline constituent is substantially independent of the absorption of all other constituents. Each will depend on the value of the absorption factor, computed for the particular constituent. Since the vapor pressure is the only physical property affecting the absorption factor, and as the vapor pressures of different constituents differ widely from each other, it follows that the absorption factors for butane, pentane, etc., in any plant operated at a definite pressure, oil rate, temperature, etc., will be inversely proportional to the vapor pressures of these constituents. For that reason the vapor pressure data of the most important gasoline constituents are listed in the following table. They are expressed both by their absolute value,[1] and by a ratio vapor pressure of butane to vapor pressure of given fraction at the same temperature. This ratio defines at the same time the ratio of absorption factors under any given set of operating conditions.

VAPOR PRESSURES OF ISOPENTANE AND NORMAL BUTANE

	——Isopentane——		——Normal butane——	
Temp. °F.	Lbs. per sq. in.	Per cent increase per 10° F.	Lbs. per sq. in.	Per cent increase per 10° F.
60	9.6	22	25.9	19
70	11.7	22	31.2	19
80	14.1	21	37.0	19
90	17.0	21	44.1	19
100	20.3	20	51.9	19

From this table it will be evident that the absorption factor of any constituent may be expressed as a ratio of the butane factor. This ratio depends on the absorber temperature but does not vary appreciably with temperature. For general use it will be convenient if the following figures are committed to memory: The propane absorption factor will in general be one-fourth, that of isobutane two-thirds, and that of isopentane two and two-thirds times that of normal butane under the same operating conditions ($\frac{1}{4}$, $\frac{2}{3}$, $2\frac{2}{3}$).

In an earlier part of the paper it has been shown that an absorption factor of 1.3 will be required to obtain with a "standard" (16-plate) absorber a 99 per cent extraction of any constituent.

To obtain efficient isopentane extraction it will be necessary, therefore, to operate the plant with an isopentane factor of 1.30, or a butane factor of 0.50. Since isopentane is unquestionably a desirable constituent, this will in general be the lowest butane factor at which a plant should be operated. Under these conditions about 50 per cent of the butane content of the rich gas would be extracted.

If a higher butane extraction were desired, for instance 80 per cent of the available butane, the butane factor would have to be raised to slightly above 0.8. In that case the isopentane factor would be about 2.1. It will be noted, by refering to Diagram 1, that in that case an absorber having eight theoretical plates would extract 99.7 per cent of the available isopentane, or be adequate. On the other hand the oil circulation, to obtain the desired butane extraction, would have to be raised only a few per cent if the number of theoretical plates were reduced from 12 to 8. This will serve as an example of conditions under which a smaller number of plates may be permissible. Even in this case, however, it could be shown that the small savings due to the larger number of plates will pay for the increased cost of the absorber.

If complete butane extraction is desired, the butane factor has to be raised to about 1.3. The isobutane factor in that case would be about 0.85, or about 15 per cent of the available isobutane would be lost. For complete extraction of isobutane, the butane factor would have to be raised to nearly 2.0.

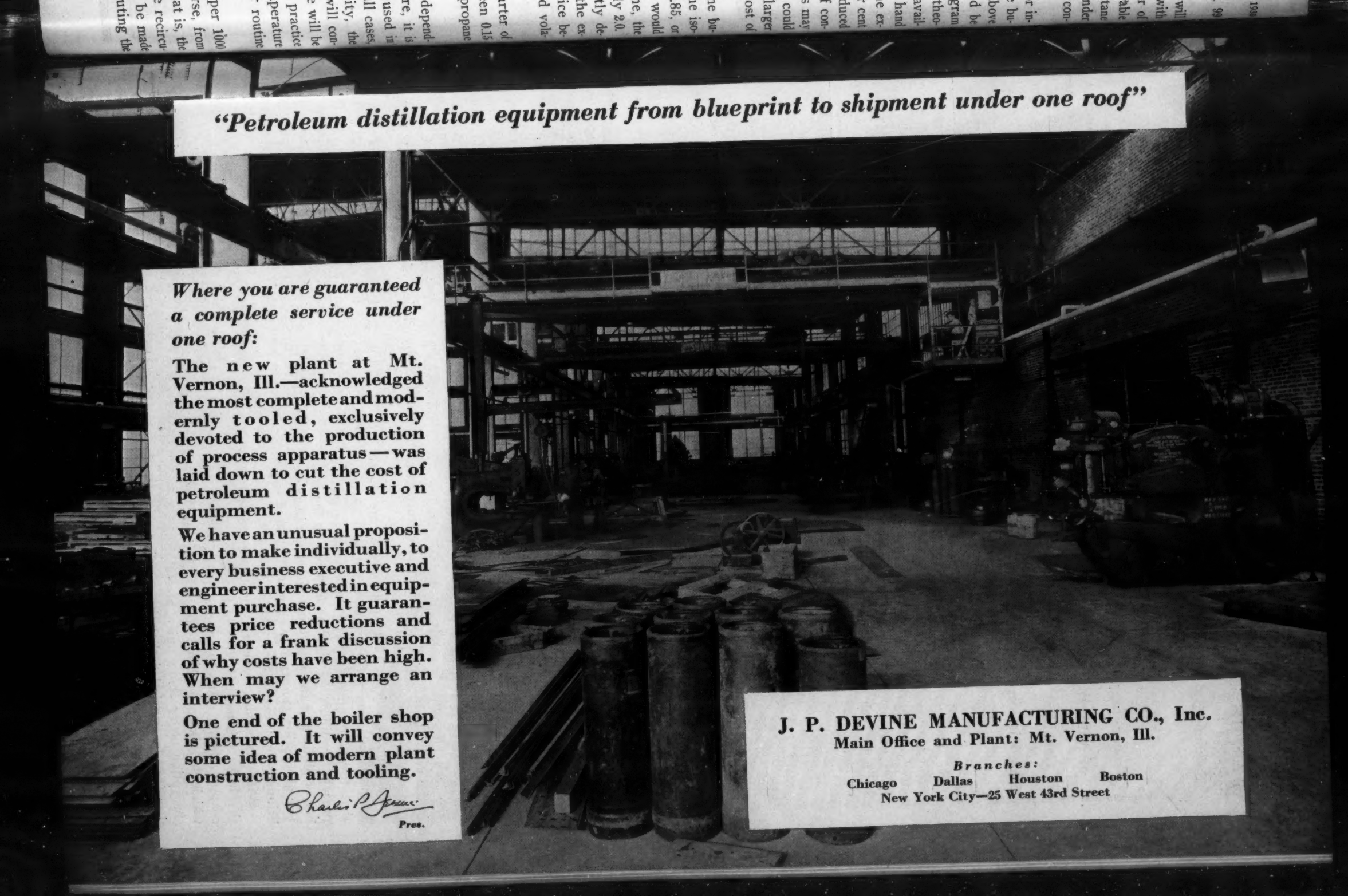
The value of the butane factor of correctly designed plant should lie, therefore, between the extremes of 0.5 and 2.0, and in average practice between 0.60 and 1.30, depending on the desired volatility of the finished gasoline.

Since the propane factor is about one-quarter of the butane factor it will lie as a rule between 0.15 and 0.30 or 15 to 30 per cent of the available propane will be extracted in the absorber.

(g) Miscellaneous Details.—Due to the dependence of the absorption factor on temperature, it is important that the correct temperature be used in the computations. It can be shown that in all cases, where the absorption factor is below unity, the equilibrium at the bottom of the absorber will control. With large factors the top temperature will be more significant. To insure conservative practice it is recommended, however, that the temperature of the oil leaving the absorber be used for routine computations.

The oil rate G is expressed in gallons per 1000 cubic feet. It should be computed, of course, from the volume of gas entering the absorber, that is, the rich gas plus any plant vapors that may be recirculated to absorber intake. Allowance could be made also for the enrichment of the oil in computing the

[1]Taken from diagram: "Vapor Pressures of Hydrocarbons," for the Natural Gasoline Association of America by G. G. Brown, H. B. Coats, P. A. Badger, Engineering Research Department, University of Michigan, April, 1928.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oil rate. This is a refinement, however, that may be neglected in average practice.

Summing up, the best procedure will be to compute the absorption factor from the liquid rate, gas rate and temperature prevailing at the bottom of the absorber. Any error introduced thereby will be in the direction of conservative practice. That is, will insure operating conditions which will result in somewhat more efficient extraction than the computations would indicate. In exceptional cases it may be desirable, however, to compute the factor both for the bottom and top of the absorber, to determine the limits between which results may be expected to vary. This applies only to plants in which the enrichment of the oil is high, such as vapor recovery plants or high pressure plants.

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VAPOR PRESSURE DATA

Temp. °F.	Propane Lbs. per sq. in	Ratio	Isobutane Lbs. per sq. in.	Ratio	Normal butane Lbs. per sq. in.	Ratio	Isopentane Lbs. per sq. in.	Ratio	Pentane Lbs. per sq. in.	Ratio	Hexane Lbs. per sq. in.	Ratio
50	91	0.23	32.6	0.66	21.3	1.00	7.6	2.8	5.4	3.9	1.5	14.2
60	.106	0.24	39.0	0.67	25.9	1.00	9.6	2.7	6.8	3.8	1.9	13.5
70	.123	0.25	46.4	0.67	31.2	1.00	11.7	2.7	8.4	3.7	2.5	12.6
80	.141	0.26	54.3	0.68	37.0	1.00	14.1	2.6	10.3	3.6	3.1	11.9
90	.163	0.27	63.5	0.69	44.1	1.00	17.0	2.6	12.7	3.5	3.9	11.3
100	.186	0.28	73.6	0.70	51.9	1.00	20.3	2.5	15.3	3.4	4.9	10.6
110	.211	0.29	85.3	0.71	61.0	1.00	24.1	2.5	18.4	3.3	6.0	10.1
120	.238	0.30	97.8	0.72	70.5	1.00	28.5	2.5	21.8	3.2	7.4	9.5

2. EFFECT OF GASOLINE CONTENT OF LEAN OIL

The analysis so far has been based on the assumption that the lean oil entering the absorber is perfectly stripped, that is, contains no gasoline fractions. This condition is rarely fulfilled. The effect of the gasoline content of the lean oil on extraction is defined by the second term in equation 18 and may be written:

$$\frac{100\,y_1}{y_0} = \frac{100(A^n - 1)A}{A^{n+1} - 1} \qquad (25)$$

y_1 is the gasoline content of the discharge gas; y_0 the gasoline content of a gas in equilibrium with the lean oil containing x_0 per cent of gasoline. A is the absorption factor, n the number of theoretical plates.

The relations defined by equation (25) are shown in graphical form in Diagram 2. It will be noted that the gasoline content of the discharge gas approaches equilibrium with the lean oil, as the number of plates and the absorption factor are increased. For absorption factors above 1 and 12 plates equilibrium is fully established, that is $y_1 = y_0$.

With reasonably efficient strippers, the lean oil should be substantially free of butane. Its gasoline content should, therefore, consist of fractions for which the above conditions for equilibrium, that is, absorption factor above unity, are fulfilled. It may, therefore, be concluded that the gasoline content of the lean gas due to imperfect stripping of the oil corresponds to the equilibrium content computed from the gasoline content of the lean oil.

This equilibrium content may be computed from equation (4):

$$\frac{y_1 v P}{1000} = \frac{r x_0 p}{100} \qquad (4)$$

The right hand member of this equation represents the vapor pressure p_0 of the lean oil due to any one constituent. This relationship may be applied to different constituents as follows:

$$\text{Pentane } y_{1\,pent} = \frac{1000}{P}\,\frac{p_{0\,pent}}{v_{pent}}$$

$$\text{Hexane } y_{1\,hex} = \frac{1000}{P}\,\frac{p_{0\,hex}}{v_{hex}}$$

No great error will be introduced if an average value of 27.5 is substituted for v_{pent} v_{hex}, etc., the vapor volume per gallon. In that case the summation of the terms on the lefthand side will give the total gasoline content $y_1 = y_{1\,pent} + y^1_{hex} + \ldots$ of the lean gas, due to the total vapor pressure $p_0 = p_{0\,pent} + p_{0\,hex} + \ldots\ldots$ of the lean oil, or

$$y_1 = \frac{1000}{27.5P}\,p_0 \qquad (26)$$

For general practice it will be preferable to express the vapor pressure of the lean oil in mm. of mercury, in which case equation (26) may be written.

$$y_1 = 0.7\,\frac{h_0}{P} \qquad (27)$$

y_1 is the gasoline content in gallons per 1000 cubic feet of the discharge gas, due to a vapor pressure of the lean oil amounting to h_0 mm. of mercury at absorber temperature. P is the absorber pressure in pounds per square inch absolute.

The lean oil vapor pressure is, therefore, a convenient criterion of stripper performance and of the losses due to imperfect stripping. The vapor pressure referred to is that of a gas free sample. Care must be taken, therefore, to eliminate the effect of dissolved gases, either by applying suitable corrections or by choice of a method which is little affected by the presence of fixed gases.

It will be evident from equation (27) that it will be desirable to maintain h_0 as low as possible. This can be accomplished by efficient stripping and by adequate cooling of the lean oil. The effect of temperature particularly can best be illustrated by an example. Assuming that the lean oil be stripped to a vapor pressure of 5 mm. at 70° F., it would have at 90° F. a vapor pressure of about 8 mm. With an absorber pressure of 30 pounds per square inch gauge the corresponding richness of the discharge gas would be 0.078 and 0.125 gallons/1,000 cubic feet respectively. The losses due to operating such a plant with lean oil at 90° F. as compared to 70° F. would amount to 0.047 gal-

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lons/1,000 cubic feet, or with a plant handling 10,000,000 cubic feet per day to 170,000 gallons of gasoline per year. This example will serve as another illustration of the importance of adequate cooling of the lean oil.

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Efficient stripping is less important in high pressure plants. The losses computed in the above example would be reduced from 170,000 gallons to 24,000 gallons per year, if the absorber pressure would be increased to the 300 pounds per square inch gauge.

Summing up, it may be stated that efficient stripping of the lean oil and adequate cooling have an important effect on efficiency of extraction. The only partial remedy against inefficient stripping lies in high pressure absorption. It will, therefore, in general be more economical to use an absorption oil of relatively high boiling points which can be stripped effectively in the available steam stills, than to use a lighter oil with inadequate stripping, because an increased oil circulation will compensate for the lower absorption efficiency of the heavier oil while no remedy can be had against inefficient stripping.

3. SELECTIVITY OF THE ABSORPTION PROCESS

The theoretical analysis presented permits of some definite conclusions as regards the selectivity of the absorption process. With a given number of theoretical plates, the butane factor to give any desired extraction of butane can be computed from Diagram 1, similarly the absorption factors, and, therefore, the percentage extraction of propane and pentane corresponding to the assumed extraction of butane. By repeating the process a diagram can be drawn similar to Diagram 3, which graphically illustrates the selectivity of the absorption process.

It will be noted that it would be impossible to obtain complete pentane recovery in a single plate absorber, without also extracting all the available butane and propane. On the other hand with a 16-plate absorber pentane recovery is complete, if only 35 per cent of the available butane is extracted. At the same time only 10 per cent of the available propane content of the gas will be absorbed in the rich oil.

These relations clearly illustrate another advantage of using an adequate number of plates in the absorber. The selectivity of the absorption process is thereby increased and any desirable extraction of valuable constituents can be obtained with a minimum extraction of undesirable ones, and therefore a reduced load on stills, condensers, cooling towers and rectifying equipment.

4. CONCLUSIONS

A mathematical analysis of the absorption process has been presented which permits an evaluation of all important variables entering the problem. The most important conclusions are:

(a) Butane Factor.—The effect of the most important variables, namely, pressure, oil rate, temperature and physical properties of absorption oil may be defined by a single term, designated as "butane factor." This factor is of such profound significance that it lends itself for a ready comparison of plants of widely different design. If this factor is known, definite conclusions may immediately be drawn as to the possible extraction of different constituents. This factor will serve, therefore, to characterize the type of plant and its size. Its general adoption by the industry would facilitate interchange of information and standardization of practices.

(b) Number of Plates.—A minimum number of 16 plates is recommended for standard absorption practice. In special instances it may be found economical to use a larger number of plates. It is shown that an adequate number of plates will in general be more important than a high plate efficiency.

With 16 plate absorbers the butane factors for efficient extraction of isobutane, butane, isopentane and pentane are approximately 2.0, 1.3, 0.5, 0.35 respectively.

(c) Temperature.—The importance of efficient cooling of the absorption oil is pointed out. The butane factor is increased about 2 per cent for every one degree decrease of the oil tempertaure. Also the losses due to inefficient stripping of the lean oil are reduced by lowering its temperature.

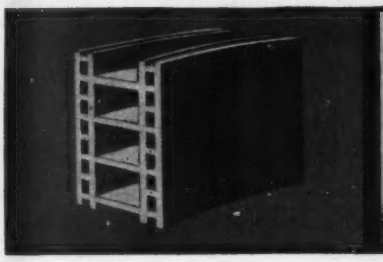
(d) Gasoline Content of Lean Oil.—A formula is presented for computing the losses due to the gasoline content of the lean oil. It is pointed out that with a fixed absorber pressure it is impossible to compensate for inadequate stripping by increasing the oil rate. This conclusion has also an important bearing on the selection of absorption oil. It should primarily have such physical properties as to insure efficient stripping with the equipment available in the plant.

(e) Selectivity of the Absorption Process.—A diagram is presented which illustrates the selectivity of the absorption process. It is shown that the selectivity is increased materially by providing an adequate number of plates. Other things equal the selectivity of the process is increased, the lower the temperature at which it is carried out. This effect is not pronounced, however, in the normal operating range.

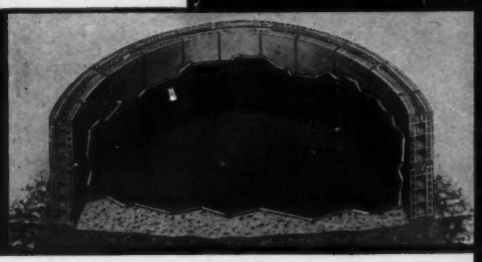
(f) Application to Practice.—The relations presented in this paper are based purely on mathematical analysis, without reference to empirical data. Their value has been demonstrated, however, by their successful application to practice conditions encountered in over 40 gasoline plants. They have been a valuable aid in the design of plants, control of operations and evaluation of test data.

TO KEEP TEMPERATURE CONSTANT IS TO INCREASE PROFITS

(Right) Close-up showing piping and roof construction of Chill Tanks, also Natco SegmenTile enclosure walls. Carnegie Refining Co., Carnegie, Pa.



A Natco SegmenTile unit is cut radially. Note the Double Shell feature.



Cross-section showing two courses SegmenTile. Note curvature in wall. Ends are cut to any radius depending on diameter of tank.

Battery of six tanks for hot stock, enclosed with Natco SegmenTile. Size 16 feet x 18 feet—capacity 30,000 gallons each. Oil is kept at constant temperature of 120 degrees Fahrenheit. Carnegie Refining Co., Carnegie, Pa.

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Refiners May Market Fixed Gas in Tank Cars

(*Continued from page 75*)

heat units in an even larger volume of gas than by merely vaporizing it. Once this gallon of propane becomes a gas in the holder, it must be distributed through a pipe line system to the ultimate consumer, and if this be a low pressure distribution system (five pounds or less) this one gallon of propane of 93,000 B.t.u. will occupy a space approximately 200-1000 times the space it would occupy as a liquid.

"If it be kept in the liquid state, it may be marketed by tank cars wherever there are railroads, and tank trucks wherever there are good roads.

"This becomes a simple question in economics. Is it cheaper to deliver one cubic foot of liquid by tank car or 277 cubic feet of gas by pipe line to get the same number of B.t.u. to the ultimate consumer? Any saving in favor of the delivery of liquid propane adds to its value as a gas holder."

Mr. Nichols pointed out also that propane is ideal both as fuel and as a refrigerating medium for dining cars and similar uses.

"The cracking units which are now in operation in this country are a potential source of 900,000,000 gallons of propane per year. The heating value of this quantity of propane is equivalent to eighty trillion B.t.u. or about 30 per cent of the manufactured gas industry of today. The volume of available butane is equal to that of propane, or even greater.

"Since the gasoline from cracking today is seven times what it was 10 years ago, the potential source of propanes and butanes from cracking alone in another 10 years may be four to five times the heating value of the total manufactured gas industry of today.

"In addition Mr. Oberfell of Phillips Petroleum Company estimates that there are 13,000,000 gallons of propanes and butanes per day available from the natural gasoline industry. This is the equivalent of 430 trillion B.t.u. per year or about 1½ times the total produced by the manufactured gas industry."

"The Economies of Reforming Refinery Gases," was discussed by C. A. Schlegel, United Engineers and Constructors, Inc., Philadelphia, and "The Refinery Gas Reforming Plant at Chester, Pennsylvania," by R. G. Rincliffe, Philadelphia Electric Company.

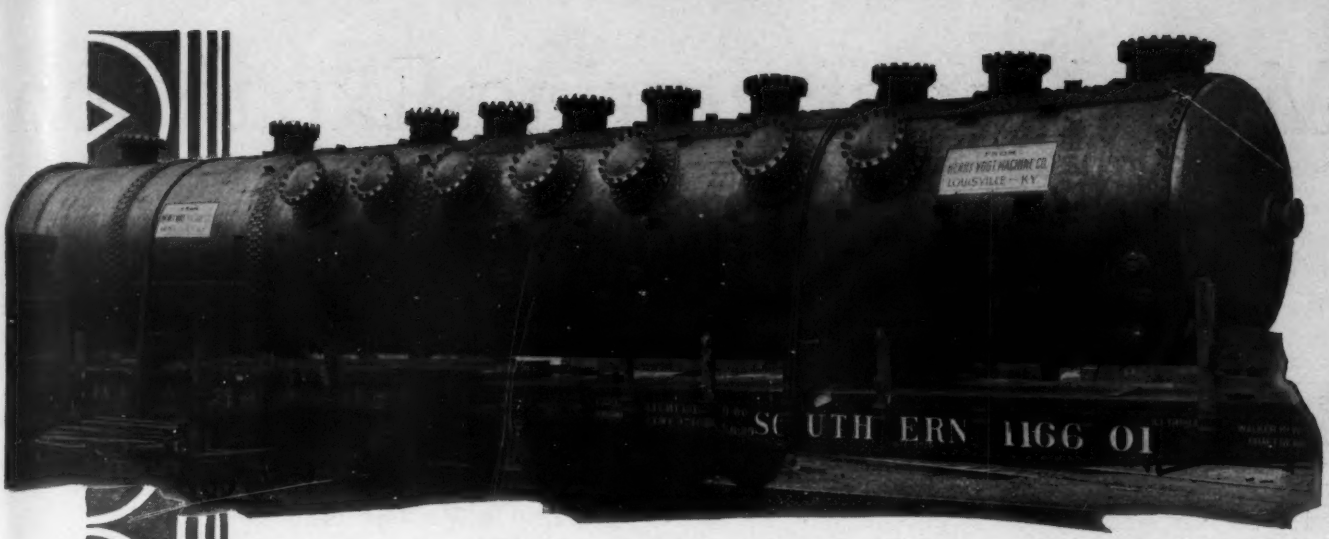
Progress in Vapor Phase Cracking

(*Continued from page 74*)

stability over a period of five or six months. In the following table are reported the results of one such test carried on under storage conditions in Florida, where the high temperatures cause the gum forming reaction to proceed rapidly. Tanks No. 1 and No. 2 were transferred each week by means of a pump so as to observe the effect of increased contact with the air. Tanks No. 3 and No. 4 were not disturbed, but were in free communication with the air. It should be noted that fuels showing as much as 0.0100 grams of gum per 20 c.c. by this method give no trouble with present automobile engines, but above this figure some makes begin to experience difficulty.

	No. 1	No. 2	No. 3	No. 4
Nov. 9th	.0011	.0014	.0017	.0017
Nov. 16th	.0024	.0016	.0021	.0020
Nov. 23rd	.0027	.0029	.0026	.0028
Dec. 14th	.0045	.0037	.0036	.0037
Dec. 21st	.0039	.0048	.0038	.0039
Dec. 28th	.0050	.0041	.0039	.0041
Jan. 4th	.0043	.0049	.0041	.0041
Jan. 11th	.0051	.0044	.0042	.0043
Jan. 25th	.0054	.0048	.0043	.0045
Feb. 8th	.0056	.0052	.0046	.0047
Feb 15th	.0056	.0061	.0048	.0049
March 8th	.0067	.0061	.0052	.0052
March 15th	.0063	.0069	.0053	.0056
March 22nd	.0071	.0067	.0055	.0058
March 29th	.0064	.0069	.0055	.0057
April 5th	.0069	.0065	.0054	.0058
April 12th	.0067	.0064	.0055	.0059
April 19th	.0065	.0062	.0054	.0059

The fuel used in these tests was handled in drums at the refinery and was some four to six weeks old before the test began. Although subjected to much worse conditions of storage than prevail in the marketing of motor fuel this product is still harmless from a gum standpoint after six months. The cost of this stabilizing treatment is very nominal, not exceeding five cents per hundred gallons for most materials. The refiner is able therefore to secure the benefits of high temperature vapor phase cracking without loss of yields, without excessive operating costs, and without fear of the stability of his product when comparing his operation with liquid phase operations. In the light of these facts the lower installation cost and the lower operating pressure combined with the small volume of oil under treatment at any time offer an incentive for the refiner to adopt vapor phase cracking, even if the high anti-knock quality of the product were disregarded.



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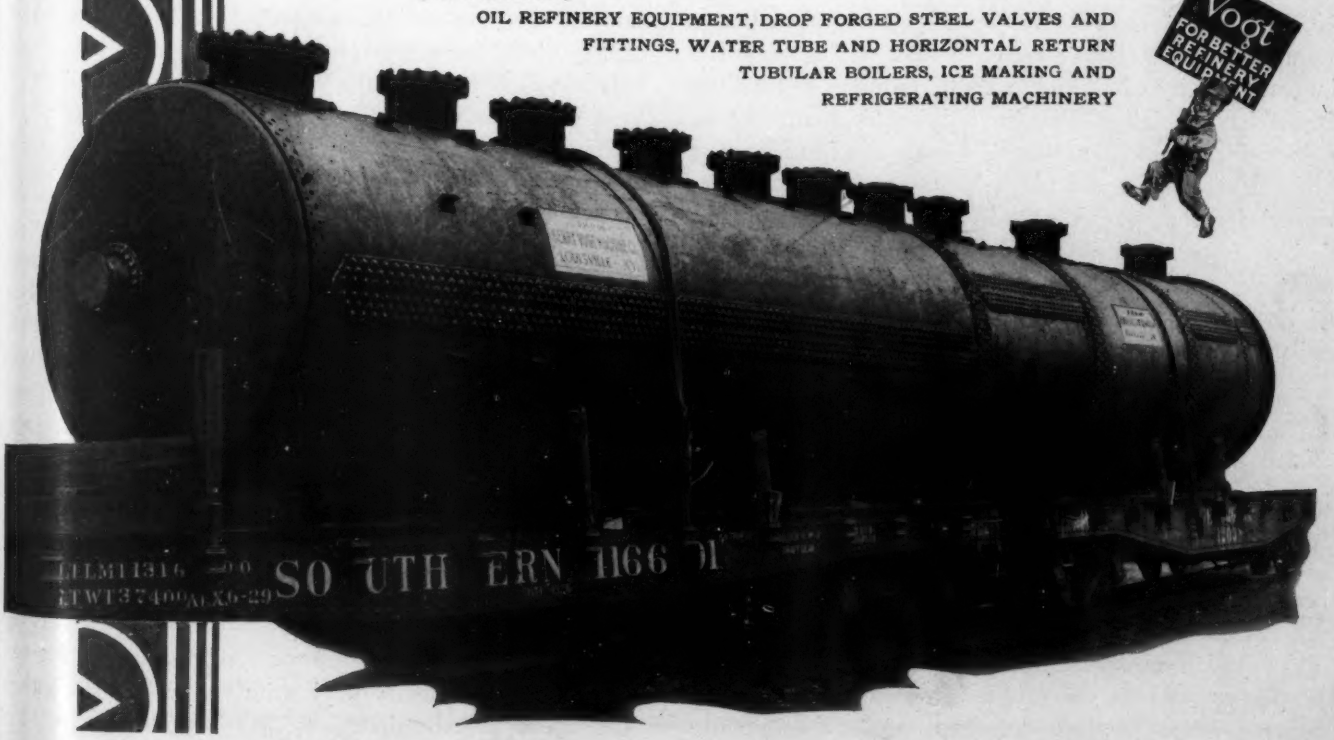

More Manufacturing Expansion Indicated

FURTHER expansion in the manufacturing branch of the petroleum industry is shown by a resume of activities reported during the past 30 days. One new domestic refinery has been announced and four new plants proposed in foreign countries. Five companies have announced new natural gasoline extraction plants in this country. In addition a number of companies have announced expansion and enlargement programs to be completed this year.

Continental Oil Company will build a 2000-barrel refinery at Denver, and will include cracking units in the construction program.

Shell Oil Company of Canada is to erect a 4000-barrel plant near Vancouver, British Columbia, and site has been purchased. At Santa Cruz de Penerisse, Canary Island, Compan Espanola de Petroles will build a 5000-barrel refinery and contracts have been let. Among the proposals is a refinery at Moscow with a capacity of 6,000,000 barrels annually to be erected by the Russian Government Oil Trust, slated for completion during the 1932-33 operating year. The government of Colombia, South America, is reported considering the erection of a refinery in the near future at a site available near Buenaventura, with an initial capacity of 2000 barrels daily.

Standard Oil Company of Louisiana is adding four 10,000-barrel combination two-stage atmospheric-vacuum units at Baton Rouge which will give it the largest capacity of this type in the industry — totalling 50,000 barrels daily. Atlantic Refining Company is constructing four units of the de Florez cracking process at its Philadelphia refinery which are reported as designed for the production of 4000 barrels of gasoline daily. Empire Oil & Refining Company has enlargement or replacement programs underway at a number of its plants, and has recently purchased 12 pressure stills for use in new cracking units.

GULF Refining Company is rebuilding its burned equipment at Bayway, New Jersey, after the fire of May 8. Standard Oil Company of Ohio is enlarging its wax removal facilities at Cleveland. Current reports regarding hydrogenation stated that Standard Oil Company of New Jersey at its Bayonne plant will have the first commercial unit of the hydrogenation process in operation late in August.

Ashland Refining Company has acquired the physical properties of the Tri-State Refining Company at Kenova, West Virginia. Directors of the Paragon Refining Company, Toledo, Ohio, have accepted an offer for purchase from the Union Trust Company, Pittsburgh, who represent the Mellon interests and Gulf Oil Corporation. Valvoline Oil Company, acquired last year by Paragon will not be included in the deal. Reece Allen, at Wichita Falls, Texas, has again entered the refining circles of North Texas through the purchase of the Olney Oil & Refining Company at Olney, Texas, from O. T. Anderson.

Two new absorption type natural gasoline plants were announced for the rapidly developing producing area of southeastern New Mexico. Shell Petroleum Corporation has purchased a site for a plan in this section, and Amerada Petroleum Corporation is planning the construction of a plant near Hobbs. Last month Texas Pacific Coal & Oil Company announced a new plant for this area.

In California, Pan American Oil Corporation has been granted permit to build an absorption plant in the Potrero town lot field, and this was followed by a permit granted to Edington-Witz Refining Company to erect a second absorption plant for this field. In Gray County, Texas, Phillips Petroleum Company is building its forty-seventh gasoline plant which is to be completed about August 1.

Two plants were reported sold during the past few weeks. Continental Oil Company has acquired a 9000-gallon plant from Carter Oil Company, which is located in Natrona County, Wyoming. In the Panhandle area of Texas, J. M. Huber Petroleum Company has purchased a 15,000-gallon plant and other properties from Pacific American Gasoline Company.

PHILLIPS Petroleum Company has authorized an increase in the capacity of its natural gasoline plant in the south end of the Oklahoma City field from 50,000,000 to 100,000,000 cubic feet of gas daily. This announcement followed closely after the statement that the company would build a new gasoline plant in the north end of the same field. The company also announced the formation of Philokla Gas Company which will construct a plant designed to compress 25,000,000 feet of gas daily for distribution by Oklahoma Natural Gas Corporation.

Additional activities are indicated in the natural gasoline division of the manufacturing branch of the industry. It is indicated that more plants will be erected in the Oklahoma City field, which now has 16, and in the West Texas sulphurous gas district, in the Lea

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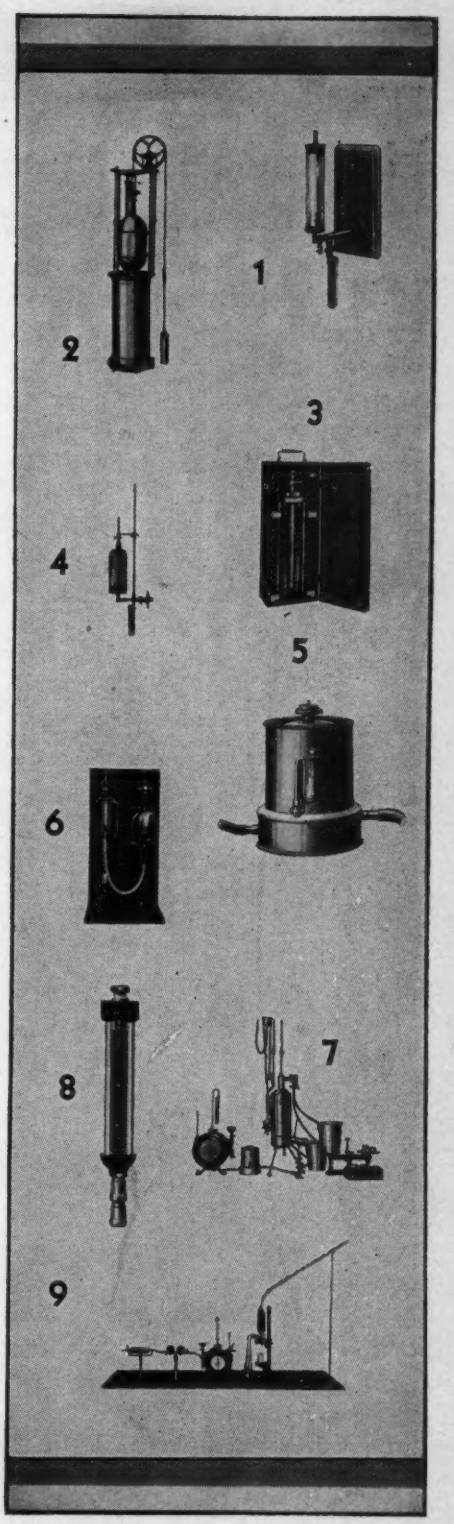
2. Cubic Foot Bottle (Immersion Type)
3. Specific Gravity Apparatus
4. Young's Sulphur and Ammonia Test
5. Calorimeter Wet Governor
6. 1/10 Cubic Foot Bottle
7. American Calorimeter
8. Siphon Gauge
9. Referee's Sulphur and Ammonia Test



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County section of New Mexico and in both northern and southern California.

Further building activity is also expected this year in the refining industry especially in regard to expansion of cracking facilities, larger refrigeration plants of direct ammonia expansion type, and degasification of debutanizing plants which are to be installed in a large number of refineries operating batteries of cracking units.

National Petroleum Association Refinery Inspection

Sixty-five representatives of the member companies of the National Petroleum Association availed themselves of the opportunity to visit and inspect the two refineries of Pennzoil Company at Oil City, Pennsylvania, May 24. This was the largest delegation yet assembled to visit a refinery under the auspices of the association. Officials of Pennzoil Company personally conducted the visitors through the plants in groups and cheerfully answered all questions pertaining to operation and construction of the manufacturing facilities.

The main plant, called No. 1, is located on Oil Creek just outside of Oil City. It operates on Bradford crude, running about 8000 barrels per day with ample capacity for a material increase in through-put when necessary. Part of the crude is run through a battery of four shell stills, and the reduced crude is passed to a Foster-Wheeler vacuum still where gas oil, neutrals and cylinder stock are produced. It is possible to take the cylinder stock overhead with this unit such is not the practice since the nature of the crude makes it unnecessary. The temperature of the oil leaving the tube still is, therefore, on 600°F. and the oil is said to be in the tubes only about half a minute.

Adjacent to the vacuum still is a Foster-Wheeler atmospheric plant into which the crude is taken direct and fractionated into skimming plant products through a large bubble tower. The still is operated at 650°F.

The wax plant, which has recently been enlarged, the centrifugal dewaxing plant, the direct ammonia expansion refrigeration equipment are all of late modern type of construction and equipment, and need no detailing here.

Plant No. 2 includes two Dubbs cracking units, a Badger pipe still and tower for rerunning, shell stills, absorption gasoline recovery plant, and continuous treating equipment. The visitors were impressed with the good housekeeping and cleanliness throughout the plant, and also with the safety measures which were everywhere in evidence. Another point of interest was the good spirit that was shown by the officials and the employees of the plant.

After the inspection the visitors were entertained at lunch in the administrations building at the company's cafeteria. President Surh made a very gracious speech of welcome to the visitors.

Those who attended the refinery visit were as follows: R. H. Baber, Ben Byron, Fred L. Way, and B. L. Heath, Freedom Oil Works Company; H. W. Walchli, A. G. Dykins, E. M. Lyons and C. R. Johnson, Tiona Refining Company; F. W. Richardson and I. L. Klein, Swan-Finch Refining Company; R. P. Wilson, D. A. Young and O. W. Walchli, Sinclair Refining Company; MacLean Houston, United Refining Company; A. W. Scott and A. W. Cole, Empire Oil Works; G. H. Seager, Viking Oil Corporation; E .R. Smith, R. C. Mason, H. G. Dunmire and Chas. M. Noyes, Valvoline Oil Company; Wm. Schwartz, Levi Smith Refining Company; M. F. Spencer and P. V. Ruhlman, Tidioute Refining Company; K. C. Northrop, H. E. Shoemaker and Russell R. Buckham, Independent Refining Company; G. C. Davison, Tri-State Refining Company; O. P. Keeney, Keeney Oil Company; W. R. Reck, Bradford Oil Refining Company; B. W. Browne and S. B. Browne, Great Western Oil Company; C. E. McElliney, Chas. H. Goss and C. H. Alsberg, Franklin Creek Refining Corporation; G. A. Kessler and G. E. McGinnis, W. H. Daugherty & Sons Refining Company; R. G. Williamson, Gerald C. Peck and Chris Petersen, Warr-Penn Refining Company; W. L. Mead, H. A. Spiegelman, D. J. Harvey, R. C. Bowman, Harry T. Francis, Willis A. Johnston, R. A. Browne, D. W. Grant, E. C. Breene, C. L. Suhr, L. D. Fulton, D. J. Cavanaugh and J. M. Hinman, Pennzoil Company; E. E. Bown, S. M. Wolbert and Lon Crawford, Kendall Refining Company; Herbert R. Ross, National Petroleum Association; Frank J. McGraw, Oil Creek Refining Company; Walter W. Beck and John A. Beck, Pennsylvania Refining Company; W. L. Gettings, A. A. Gohn and R. S. Dawson, Conewango Refining Company; W. H. Millhiser, Waverly Oil Works Company; E. E. Ebner, Emlenton Refining Company; N. H. Weber, Pure Oil Company.

New S. A. E. Viscosity Number

The Society of Automotive Engineers, lubricants division of the standards committee on May 23 at Detroit, effected a revision of S.A.E. viscosity numbers, which was approved by the standards committee at French Lick, Indiana, May 25. A new viscosity number 70, has been added to the list, and oil viscosities in Saybolt universal seconds of the various numbers now extend to minimum and maximum limits. The S.A.E. handbook now contains this note "The S.A.E. viscosity numbers constitute a classification of oils in terms of viscosity only. Other factors of oil quality or character are not considered." The revised schedule follows:

S.A.E. Vis. No.	Minimum	Maximum Less Than
10	90@130F.	120@130F.
20	120@130F.	185@130F.
30	185@130F.	255@130F.
40	255@130F.	75@210F.
50	75@210F.	105@210F.
60	105@210F.	125@210F.
70	125@210F.	150@210F.

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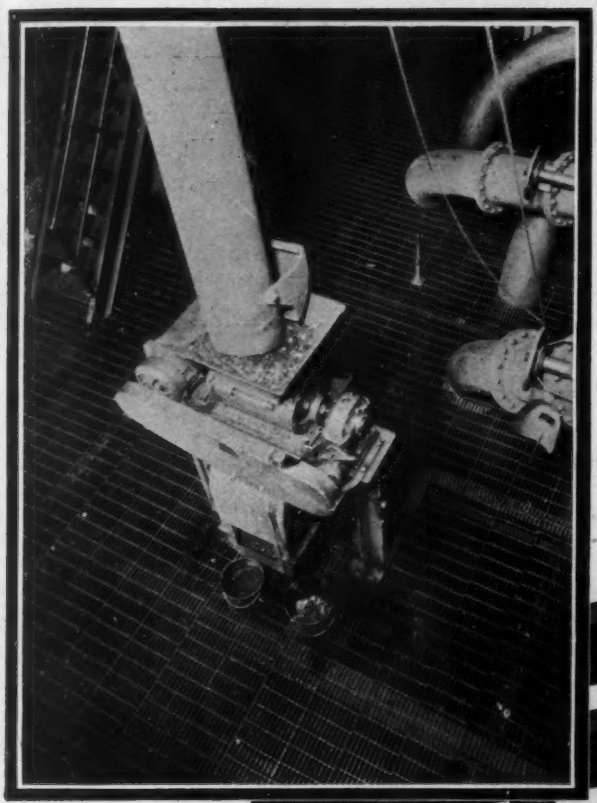

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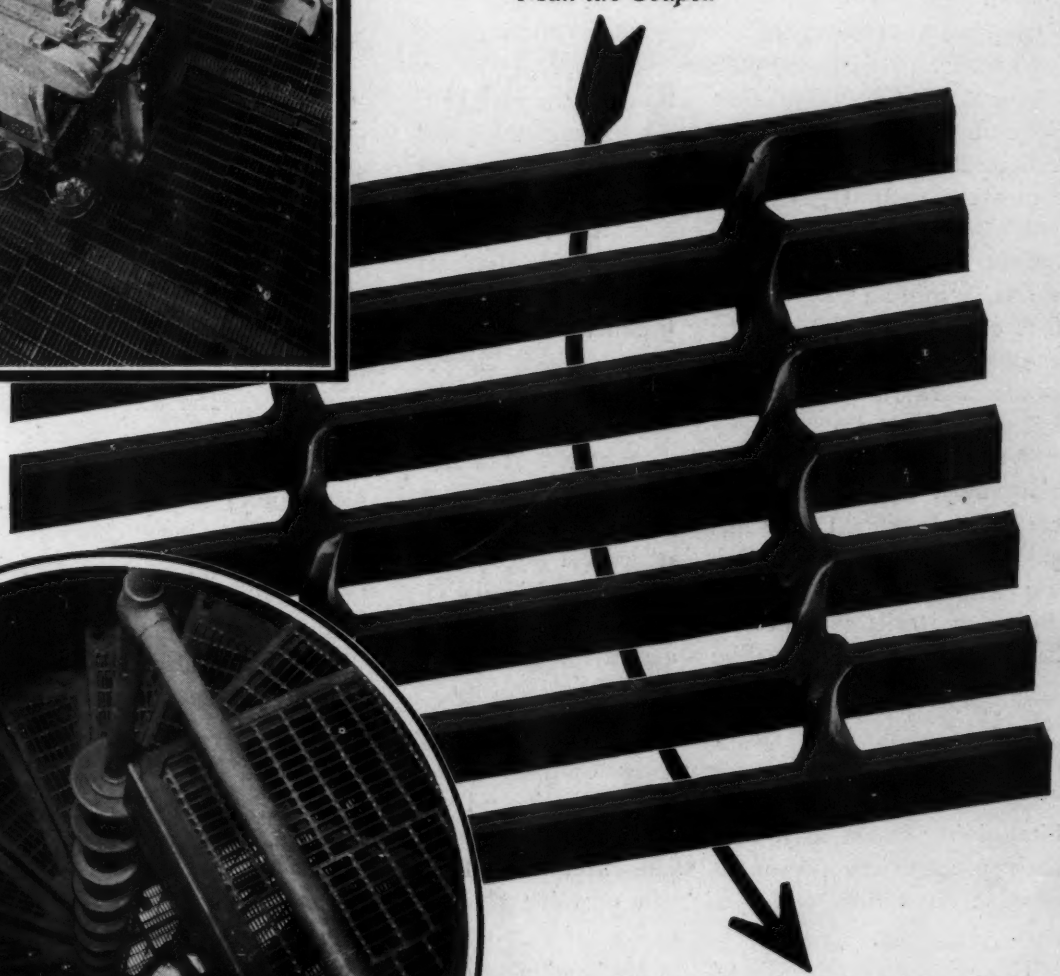

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PLANT MEN AND METHODS

By GEORGE REID

DR. E. R. Lederer, president of the Natural Gasoline Association, in his address at Tulsa sounded a warning to gasoline manufacturers which points to the fact that care must be exercised in regard to the increasing volume of gasoline produced. He pointed to Oklahoma City, West Texas and the New Mexico area as districts where increased gasoline manufacturing is contemplated. To this may be added additional plant construction contemplated in California.

Dr. Lederer pointed to statistics for the past two years and showed that the refining industry had been able to absorb a 28 per cent increase in natural gasoline production in 1929 over 1928. This increase amounted to 417,000,000 gallons. Total production in 1929 was 2,195,400,000 gallons. However, the year 1930 is getting under way with a larger increase than was indicated as actually needed. Petroleum economists estimate a natural gasoline consumption this year of 143,000 barrels or 6,006,000 gallons daily, and these figures permit an increase. However, as Dr. Lederer stated, according to Bureau of Mines figures for the first quarter of 1930, the daily production of natural gasolines averages 6,180,000 gallons, which figures would indicate that stocks must have increased slightly, but not alarmingly.

We wish Dr. Lederer had not added "but not alarmingly." The phrase is too comforting. The industry has maintained a very fortunate equilibrium for the past two or three years. It is just a little discomforting to note a tendency in 1930 toward a possible building up of stocks above those requirements which have been determined as normal by a number of economists.

A. J. SCHLOSSER, Barnsdall Oil Company reading papers comparing California and Mid-Continent production methods and the like, giving credit to J. E. Dale and O. Weaver for their preparation, presented some interesting facts relative the Californians and their gasoline production.

These fellows on the West Coast are handling around 52,000,000,000 cubic feet of gas daily, it is said. This volume is processed in 138 gasoline plants, of which all but one are of the absorption type.

Averaging conditions it is found that these plants produce 3.7 gallons of natural gasoline for every barrel of crude oil produced by the state. The average yield for the state is 1.4 gallons per 1000 cubic feet of gas handled. Each plant secures gas from an average of 65 wells.

Practically all of the gasoline is stabilized, and all sales contracts read 90 per cent or better recovery. No sour gasoline is treated. A little production of sour gasoline exists, but the greater proportion requires no chemical sweetening. The small production of sour gasoline is mixed with crude oil. Practically all of the gasoline is delivered to refineries in gasoline pipe lines.

The average cost of manufacture was reported at three to 3½ cents per gallon. One plant was specifically noted at Santa Fe Springs which produces 145,000 gallons daily of 94 per cent recovery gasoline at a cost figure of 2½ cents per gallon.

M. E. FOSTER, sales manager, Phillips Petroleum Company, reporting for the sales manager's committee of the Natural Gasoline Association at its Tulsa convention made some interesting observations. Stating that the natural gasoline industry had increased its production 100 per cent in the past five years there had been fairly well stabilized prices during this period, especially during the past two years. Refiners use about 90 per cent of the industry's production and therefore natural gasoline prices must be in line with U. S. motor fuel price. The increasing production of naturals has been absorbed by the refining industry with such newer markets as aviation fuels, export grades, and the like contributing some to demand. It has been possible through the sales efforts of the industry, its sales promotion through research, and the acceptance of natural by its logical customers, to maintain stability of stocks and price. Due to the fact that the industry is looking for perhaps a large increase in gasoline production this year Mr. Foster stressed the fact that real sales efforts must be continued to an intensive degree.

THE Natural Gasoline Association of America continues to grow. This year its president enjoyed the pleasure of welcoming into the fold Hanlon-Buchanan, Inc.; Anglo Persian Oil Company; Columbian Gasoline Corporation; Crosbie & Moran; and Gillespie-Moran. At last spring's meeting, if we recall rightly, another list of new members was announced. More can conveniently come in. And any association that can accomplish as much in as few years as this association has achieved, and can hold annual meetings which develop into sessions of real interest and great value to the petroleum industry, deserves such growth.

These meetings have a way of getting up momentum and proceeding to a successful conclusion with an enviable smoothness. Sessions morning and afternoon,

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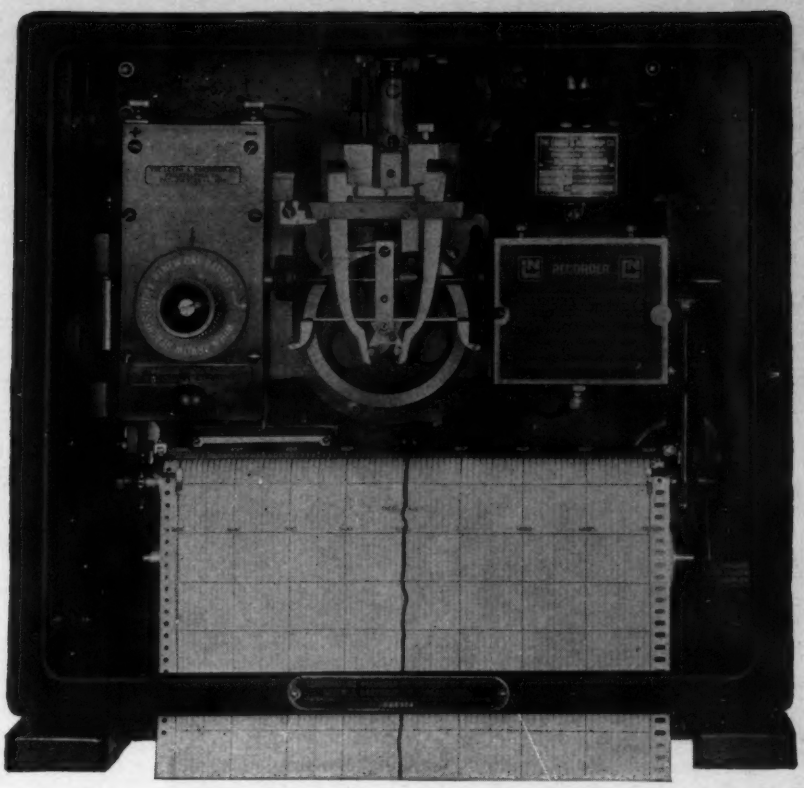
. . . Oil Refining



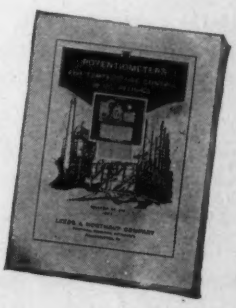
Actual Width of Chart is 9⅞ Inches

Oil Refining depends upon so many little things for its success—just a few degrees "off" at one point, circulating flow just a bit away from what's right—any one of a score of "mighty nothings"—and your production schedule goes to pieces! Small wonder, then, that the average still operator is inclined to look for *strength* in instruments used to keep track of temperatures. Watch your men when they first see an L&N Potentiometer Pyrometer! Built ruggedly . . . motor driven . . . yet noting changes as small as 2½ parts in 1,000!

Confidence, felt at first sight, is strengthened every time this rugged potentiometer instrument is used. It takes but a moment to be sure that an L&N Pyrometer is telling the truth, that its sturdy parts are in perfect working order. And this dependable service will be rendered year after year.

Thermal Engineers Available for Consultation at Your Plant

Full details of how L&N Potentiometer Pyrometers can benefit your production are given in our special bulletin for Oil Executives. Better yet would be an advisory survey.



Learn of the many ways that L&N Pyrometers can help in Oil Refining. Send for Bulletin No. 870-R

P-187

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L&N Potentiometer Pyrometers—Different From All Others—Most Accurate In Industry

directors meetings, Dutch lunches each day, smokers and dances at night, always punctual, no confusion, everything ready. But there is a man behind that job of hard work, and although he staged his first convention only last spring, he is performing like an old hand at the ringmaster's trade. This fellow is Ray E. Miller, secretary of the Natural Gasoline Association of America.

TONY VESCOVI

D. B. KELLY

D. B. KELLY, above and at the right, was for many years superintendent of refinery operation for American Refining Company at Wichita Falls, Texas. "D. B." is now looking after the operation and enlargement of Globe Oil & Refining Company's refinery at Lamont, Illinois. At the left is Tony Vescovi, right-hand-man and chief chemist at the refinery, who checks up on the operation of distillation and chemical treating systems with a firm hand and in a new and commodious and well lighted brick and concrete laboratory—which, incidentally, is a whale of a lot more than "D. B." provided for one George Reid to supervise the same type of work in the Wichita Falls plant in 1924.

Under the direction of D. B. Kelly the Lamont plant has been completely revamped and modernized. For a while the plant ran on Muskegon crude barged in from the Michigan fields. Now the plant is processing Mid-Continent crude delivered to the plant by pipe line. The statement that a superintendent should be mightly glad to swap Muskegon crude for Mid-Continent just any time brought the smile we see in the picture. It should also have brought a sigh of relief. (We think Chief Chemist Vescovi evinced a full grown sigh.)

At present there is more enlargement and expansion under way at the refinery, including more capacity at the loading racks, a larger continuous treating system, and a new combination skimming and cracking unit of 6000 barrels capacity. There will be more about that later.

SUBSTANTIAL earnings were recorded during the year 1929 from the two natural gasoline plants operating on sulphur contaminated gas in the Big Lake field, West Texas district. Big Lake Oil Company's plant, which is supplied with gas from the 2500- and 3000- foot horizons recorded a total production of 5,703,129 gallons during 1929, with a net profit for the year of $53,331.46 after deducting depreciation. The output of the plant was averaging 20,000 gallons daily at the close of the year, and is scheduled to increase capacity and production during 1930 because the company has a number of oil and gas producers scheduled for completion during 1930 from the 8220-8600-foot lime horizon. Signal Gasoline Company of Texas, which is owned 50-50 by the Group One Oil Corporation and Signal Oil & Gas Company, reported net earnings, before depreciation, of $115,624.04 during the year 1929. This plant is largely supplied with natural gas from Group One Oil Corporation's University 1-B, which is producing oil and gas at 8500-23 feet, with some gas also taken from wells producing from the 3000-foot horizon. Negotiations are pending for the erection of carbon black plants to take the residue from these plants, since a market is not available for the gas as fuel.

These two plants pioneered the work of gasoline extraction from the sulphurous gas production in West Texas. Some of the wells produce gas with as high as 20 per cent hydrogen sulphide content. The experiences of Big Lake Oil Company plant and the details of operations were presented in this magazine in the issue of August, 1928, page 60. The plant of Signal Gasoline Company was discussed in these columns in the issue of May, 1929, page 86.

Philips Petroleum Company was the third operator to enter the sour gas territory with gasoline extraction equipment. This company is now building its second plant to operate on sulphurous gas—located in Ector County in the Judkins field. Humble Oil & Refining Company was the fourth manufacturer to enter the West Texas area with its natural gasoline plant in the Yates field.

Despite the high cost of special equipment and the short life of standard equipment due to corrosion, alkaline water, and the like, it would appear that plant operation is still a profitable venture in West Texas. It is reported that others will enter the territory before the end of this year.

G. H. Van Senden, Shell Oil Company, California, has been promoted to the newly created position of vice-president in charge of manufacturing. Mr. Van Senden has been identified with refining work for the past 18 years.

L. R. Holmes was appointed manager of the refining department of The Texas Company, May 1, and has transferred his headquarters from Los Angeles to New York. Mr. Holmes has been vice-president of The Texas Company of California.

Gustav Egloff of the Universal Oil Products Company sailed with Mrs. Egloff on June 4 to attend the World Power Conference at Berlin.

Dr. George Granger Brown has been appointed professor of chemical engineering at the University of Michigan. His association there dates back to 1920 when he terminated several years industrial experience to become an instructor.

PROGRESS

"Here, Lad—

If we're going to adopt your friend here, ARC WELDING, you'd better start looking for some men to work with him. On what basis will you hire them?"

TRADITION

The Lincoln "Stable-Arc" Welder

— welds easier
— makes better welds
— permits greater output because of the steady uniform arc throughout entire welding range, which is the result of:

- **Variable voltage design**
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No other welder has all these features.

"Easy, Pop—

The same way as I would buy the welding machines, viz:

With Men—	*With Machines—*
Has their experience with arc welding been a full time or part time job?	The Lincoln experience in making arc welders occupies their full time thinking and working.
Have they achieved any distinction for doing a good job?	The Lincoln people originated, developed and, by close specialization achieved principles that have made commercial arc welding possible—and profitable. (See list above.)
Has their services been in demand?	Just count the Lincoln 'Stable-Arc' welders in service.
Have they set a standard that others have endeavored to emulate?	Back in 1914 when Lincoln advocated variable voltage machines they were severely criticized. Do you hear any criticism today? Lincoln specialized engineering didn't wobble. That's why they've been so successful—proving again that the will you *leave* depends upon the will you *have."*

The Lincoln Electric Co., Dept. No., 34-6, Cleveland, O.

"Stable-Arc"

LINCOLN WELDER

W-145

Refinery and Gasoline Plant Activities

New Plants – Construction Notes – Personnel Changes

Ashland Acquires Tri-State

Ashland Refining Company, Ashland, Kentucky, has acquired the physical properties of Tri-State Refining Company, Kenova, West Virginia. The merger announcement states that the two refining plants and sales organizations will continue to operate as separate organizations. Operation of Tri-State Refining Company which was chartered in Nevada, has been taken over by a newly formed company styled Tri-State Refining Company of West Virginia.

Officers of the new company are as follows: chairman of the board, Thomas A. Combs, Lexington, Kentucky. Mr. Combs is also president of Ashland Refining Company and Swiss Oil Corporation. Paul A. Blazer is president of the new company and is also vice-president and general manager of Ashland Refining Company. S. C. Davison, formerly president of the old Tri-State Refining Company is vice-president of the new organization. R. W. Grossenbach is treasurer of both companies. Homer Holt of Huntington, West Virginia, is secretary.

Included in the properties purchased is a 1400-barrel skimming plant and a Jenkins cracking plant, which are located at the junction of the Ohio and Big Sandy Rivers. Seven bulk distributing plants and 20 service stations are also included. The refinery at Kenova will be enlarged to 2000 barrels daily capacity. New fractionating and treating facilities will be installed. W. D. Manz is to continue as superintendent of plant operations.

Sales offices of Tri-State Refining Company have been moved to Ashland. W. H. Seltzer remains as sales manager for the company. E. F. Wells is sales manager for Ashland Refining Company. S. T. Rion will serve in capacity of manager of traffic for both companies.

Atlantic Building De Florez Units

Atlantic Refining Company has contracted with M. W. Kellog Company for the construction of four DeFlorez cracking units to be placed in service at its Point Breeze, Philadelphia, refinery. These units will process approximately 2500 barrels each per day of a mixture of residual stocks producing anti-knock motor fuel and residuum. Gasoline production will be above 4000 barrels daily. The estimated cost of the installation is reported at $2,000,000. The installation will include stabilization or debutanization and absorption equipment. They are expected to be in operation January 1, 1931.

Atlantic Refining Company is the first refining company other than The Texas Company and Gulf Refining Company to install units of this type. The process was developed at the refineries of the two companies mentioned. The first commercial unit was erected in 1927 at the Bayonne refinery of Gulf Refining Company, incorporating in the design the now well known DeFlorez vertical-cylindrical furnace. This unit has been operating on Venezuelan crude for the past two years using heavy charging stock under vapor-phase conditions to produce anti-knock distillate with 1000 to 2000 hours on stream. At the refineries of The Texas Company units of this type are under construction of sufficient capacity to produce 5000 barrels of gasoline daily. This work is to be completed this year.

Colombian Government Proposes Refinery

The Colombian government is reported considering the erection of a refinery at Buenaventura in western Colombia, according to reports appearing in Colombian Boletin de Minus y Petroleo. It is estimated that a daily capacity of 2000 barrels will suffice to begin with yielding gasoline, kerosene, gas oil and fuel oil. A suitable site is available near the harbor at Buenaventura. Storage facilities for 800,000 barrels of crude oil and refined products, is proposed in the report. The total estimated expenditure for tankers, storage facilities and refinery proper is placed at $2,500,000.

Gas Station Building

Colorado Interstate Gas Company, (Cities Service) has begun construction of a gas compressor station at Clayton, New Mexico. The estimated cost is reported at $500,000. Ford, Bacon & Davus are engineers.

Let Canary Island Refinery Contract

Compana Espanola de Petroles, Madrid, Spain, has awarded contract for supplying materials, erecting and putting in operation a 5000-barrel refinery to produce gasoline, kerosene, and fuel oil at Santa Cruz de Penerisse, Canary Islands, to Bethlehem Steel Company, 25 Broadway, New York, N. Y. This plant was reported as proposed in the April issue of Refiner and Natural Gasoline Manufacturer at which time reports stated that estimated cost was $1,250,000. The company controls oil lands in Venezuela, South America, and has made arrangements with the monopoly for part of its requirements. An offering of 40,000 50-peseta shares to effect an increase in capital was underwritten by Spanish banks headed by Banco Exterior de Espana.

Continental to Build at Denver

Continental Oil Company will build a refinery at Denver, Colorado, this summer, according to an announcement made by W. H. Ferguson, executive vice-president in charge of the Rocky Mountain district. A site has been secured on the Brighton road, just north of Denver, and construction is to begin at once. The charging capacity of the plant will be 2000 barrels per day, with cracking units, and will run the distillates down to coke. The type of cracking units is not disclosed. There will, however, be no production of lubricating oils, at least for the time being.

Supply of crude for the new refinery will come from the company's production in the Wellington-Ft. Collins field, and from the Rattlesnake Dome in New Mexico. The Ft. Collins field produced about 1500 barrels per day from the Muddy sand, and the lower horizons are considered favorably. The Rattlesnake field has a very high grade of oil from the Dakota series and a good grade of oil from the Pennsylvanian.

Continental Oil Company has a refinery at Florence, Colorado, and another at Glenrock, Wyoming, in the Rocky Mountain states at the present. Its wildcat acreage in eastern Colorado is considered to be of high value and probably will be drilled to develop an additional supply for the new Denver refinery.

Wyoming Plant Changes Hands

Continental Oil Company has acquired the natural gasoline plant formerly owned by Carter Oil Company in Section 5-39n-78w of Natrona County, Wyoming. The plant has a rated capacity of 9000 gallons daily and has been in operation for several years. Continental Oil Company will operate the plant and since it also operates a refinery at Glenrock, Wyoming, an outlet for gasoline production is provided.

Empire to Enlarge Plants

Empire Oil & Refining Company, a Cities Service subsidiary, has awarded contract for 12 pressure stills to be used at various refineries, to A. O. Smith Corporation. Part of this equipment is for replacement purposes. At the Ponca City, Oklahoma, refinery the company is dismantling much old equipment and installing new topping and vacuum distillation units. At the Crew Levick Company plant (also Cities Service) at Titusville, Pennsylvania, a $300,000 expansion program is under way. The installation of two Foster-Wheeler distillation units included in this program will effect an increase in capacity from 3000 to 6000 barrels daily at this plant. The site was enlarged by the purchase of an adjoining 30 acres of land last year.

Russian Refinery Planned

The Government Oil Trust, Russia, plans to build a refinery in Moscow with

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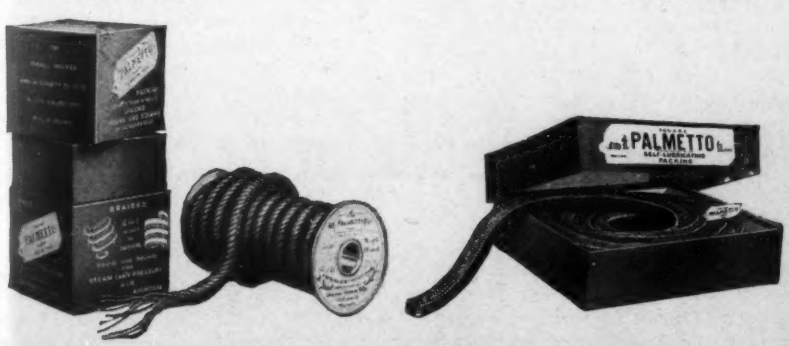


Rear Admiral **RICHARD E. BYRD**

The primary object of the Byrd Antarctic Exposition was scientific, It was not a "dash" to the South Pole, but an organized effort to explore an area never previously beheld by the human eye, equal to that of the United States and Mexico combined.

Rear Admiral Byrd and Associates

a capacity of 6,000,000 barrels annually in connection with a proposed pipe line from the Caspian Sea to Moscow which has been authorized and is being surveyed. Both of these projects are not to be completed until the 1932-33 operating year.

Gulf to Rebuild Burned Equipment

Gulf Refining Company plans to replace at once the equipment recently destroyed by fire at its Bayonne refinery. The fire damage incurred May 8 resulted in a loss totalling $2,000,000 which loss was largely confined to tanks and various grades of crude and refined products. Fire is reported to have started on a small tanker at the company's docks, spreading to the plant yard. The plant was erected about three years ago and is located on a 13-acre site formerly used as a bulk terminal station. The refinery capacity is rated at 40,000 barrels daily.

Olney Oil & Refining Company Sold

Olney Oil & Refining Company, operating a 2100-barrel skimming plant near Olney, Texas, has been purchased from O. T. Anderson by Reece S. Allen of Wichita Falls, Texas. This plant has been in operation for the greater part of seven years. Mr. Allen is one of the pioneers of refining in the Panhandle district and has been identified with refining interests in the Wichita Falls area for many years.

Panhandle Plant Sold

Pacific American Gasoline Company has sold its 15,000-gallon natural gasoline plant and oil and gas wells and gas contracts to J. M. Huber Petroleum Company, Borger, Texas. Other properties in Hutchinson County, Texas Panhandle, were included in the deal. J. M. Huber Company also operates gasoline plants and carbon black plants in the Monroe, Louisiana, gas producing area.

Potrero Gasoline Plants Going In

Pan American Oil Corporation has been granted permit to construct an absorption type natural gasoline plant on Lot 27, Block 1, Tract 146 in the Potrero field, Los Angeles Basin district of Southern California.

Edington-Witz Refining Company has also been granted permit for the construction of a similar plant on Lots 22 and 23, Block 4, Tract 146 in the same field.

These two natural gasoline manufacturers are the first to enter the town lot area in Potrero to handle the gas production from the deep sand development. The plants are to be rushed to completion and will be in operation this summer.

Paragon Sold to Mellon Interests

Paragon Refining Company, Toledo, Ohio, has been acquired by the Mellon interests according to a recent announcement from E. W. Edwards, president of the former organization. Directors of the company have accepted an offer from Union Trust Company of Pittsburgh, representing the absorbing interests and proposal is to be made to stockholders at a special meeting June 24. It is reported that Union Trust Company is acting for Gulf Oil Corporation. Paragon Refining Company operates an 8000-barrel plant at Toledo, which is equipped with 3000 barrels of Dubbs cracking facilities. The deal is reported not to include the properties of Valvoline Oil Company which were acquired by Paragon last year.

New Phillips Plant in Texas

Phillips Petroleum Company has announced the building of a new natural gasoline plant in Gray County, Texas. This plant, which will be finished about August 1, will be the forty-seventh for this concern, and its sixth in that county.

The plant has producing and potential gas reserves from 2600 acres of leases. It will operate from natural well pressure on 40,000,000 cubic feet of gas daily and has been designed to process 60,000 gallons daily. It will be of absorption type, with two distillation units and 20 compressors.

To Enlarge Oklahoma Plant

Phillips Petroleum Company has authorized an increase in the capacity and output of its natural gasoline plant in the south end of the Oklahoma City field, from 50,000,000 to 100,000,000 cubic feet a day, taking advantage of the original design of the plant which permitted a doubled production at a small additional cost of construction.

The engine room installation of this plant included in this authorization is designed not only to handle the vapors from the oil stock tanks which are rich in gasoline, but by expansion, to also permit handling the gas as it increases characteristically in natural gasoline content, after natural well pressures have declined.

This authorization, closely follows the recent announcement of the construction of a plant with a capacity of 50,000,000 cubic feet of gas in the north end of the field and assures the company of the ability to product over 100,000 gallons of natural gasoline a day from that field. The designs of the two plants provide for the interlocking of all casinghead gas, residue gas, and natural gasoline lines in such manner that the combined installations may be considered one large united system effecting closest economy of operation.

The announcement also closely follows the recent announcement of the formation of Philokla Gas Company for the construction of a plant designed to compress 25,000,000 feet of gas a day for distribution by Oklahoma Natural Gas Corporation.

New Canadian Refinery

Shell Oil Company of British Columbia, Canada, has purchased a 70-acre site for a new refinery on the water front at Burnaby, adjoining the city of Vancouver. The project, which is reported to involve the expenditure of about $4,000,000 will necessitate the erection of complete refining equipment, ocean and railway terminals. The site lies about two and one-half miles from the Second Narrows bridge and has frontage on Burrard Inlet and the Canadian Pacific Railway tracks. Near this point Seaboard Oil and Refining Company has under construction a 4000-barrel refinery, just west of the Second Narrows bridge and on the north shore. This latter plant was reported in this department in February, 1930.

Two Plants for New Mexico

Shell Petroleum Corporation has purchased a site in Section 19-19-36, Lea County, New Mexico, and plans the construction of a large natural gasoline plant of absorption type with estimated cost reported at $500,000.

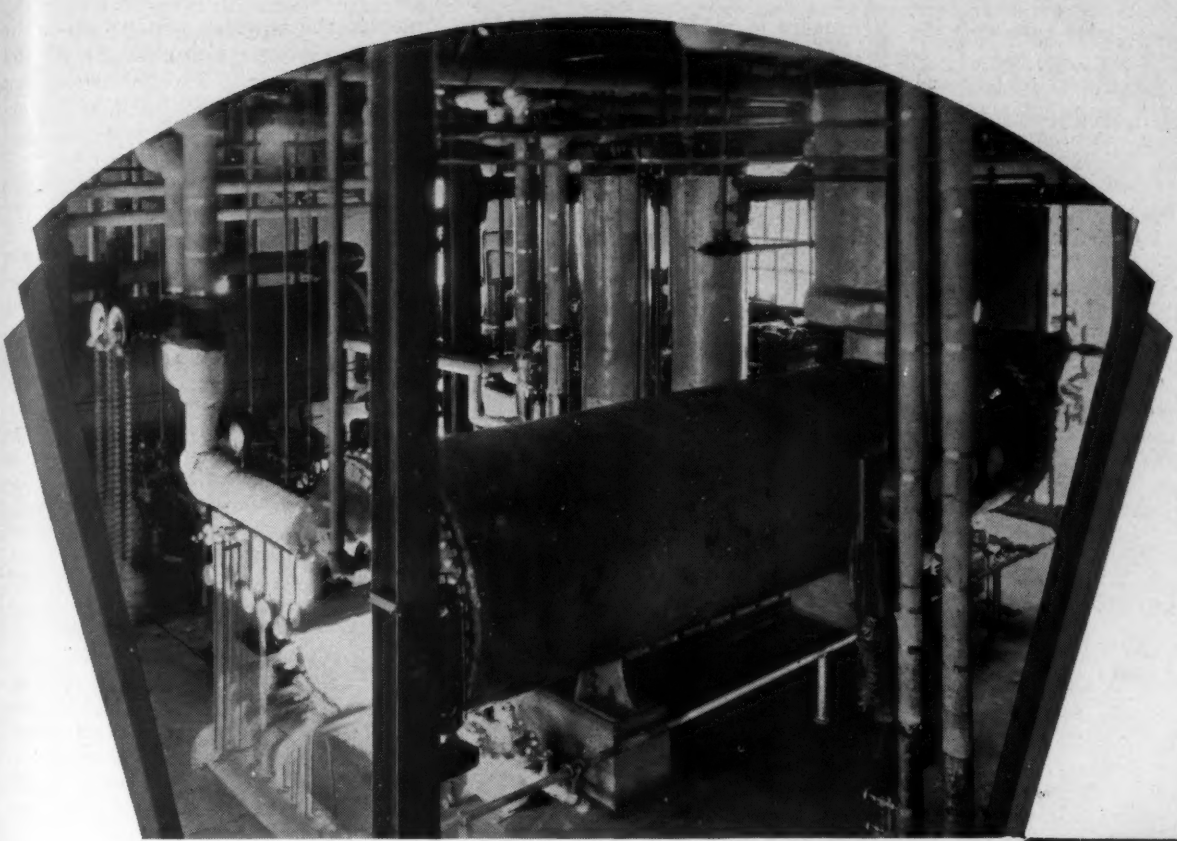
In the same territory Amerada Petroleum Corporation is planning the construction of a plant in the near future near Hobbs. This brings the total proposed plants to three for this section at present, as Texas Pacific Coal & Oil Company was first to announce a natural gasoline plant in Lea County to be located in Section 23-26. This plant was reported in these columns last month.

Instal Two-Stage Units

Standard Oil Company of Louisiana at its Baton Rouge, Louisiana, refinery is enlarging its distillation facilities through the installation of four 10,000-barrel two-stage atmospheric-vacuum distillation units, of Foster-Wheeler type. This will total four units of this type, the first having been installed about a year ago and employed in the distillation of Venezuelan crude, considerably above its rated capacity. Upon completion of this work the battery will be the largest in capacity of two-stage atmospheric-vacuum type in the industry, having a total charging rate of at least 50,000 barrels daily. These units are designed to fractionate gasoline, naphtha, kerosene and gas oil on the atmospheric side and heavy gas oil, wax distillate, heavy wax distillate, cylinder stock and flux bottoms on the vacuum distillation side.

Hydrogenation Units Nearing Completion

Standard Oil Company of New Jersey, at its Bayway, New Jersey, refinery, is reported to be well under way in the construction of the first unit of its hydrogenation process. The installation is rated at 5000 barrels daily capacity. The process employs the developments of Dr. Friedrich Bergius of Heidelberg, which work was done for the German I. G. Farbenindustrie A. G. and improved during the past three years by the researches of Standard Oil Development Company. Crude or heavy residual oils are built up by the addition of hydrogen at high pressures and temperatures in the presence of catalysts. Standard Oil Company has transferred its ownership in the United States rights of the hydrogenation patents to its newly formed subsidiary, Hydro Patents Company, which will



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On a cost of production basis plus an assurance of dependability that continues year after year, makers of America's finest lubricating oils have chosen Carbondale refrigerating and refinery machinery. Thirty years of practically continuous use has been recorded by Carbondale installations — and they are good for many more.

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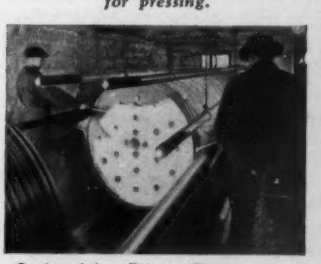

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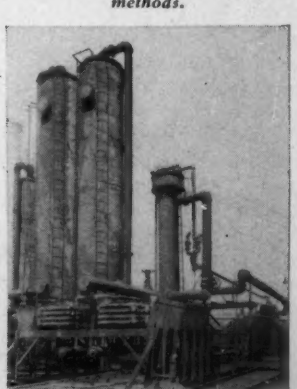


Carbondale Heat Exchanger installation.

license the process to other companies interested.

The Bayway installation is proposed for completion in August of this year. A second installation at Baton Rouge, Louisiana, at the refinery of Standard Oil Company of Louisiana, is under construction and a third is reported designed for Humble Oil & Refining Company at Baytown, Texas. Current reports state that Imperial Oil Company, Ltd., the Canadian subsidiary, plans the construction of a similar unit. Imperial Chemical Industries, Ltd., in England, is reported to have acquired the right to use the hydrogenation process in that country. A Texas refining company has unofficially indicated its plans for the construction of the hydrogenation process at a proposed new refinery in this state. From these activities it can be concluded that hydrogenation in the refining industry may soon be regarded as a definite commercial development of importance.

Enlarging Wax Plant

Standard Oil Company of Ohio is enlarging its wax pressing facilities through the addition of a new wax plant at its East 65th Street refinery, Cleveland, Ohio. E. B. Wagoner is manager of construction for the company. Contract for the building has been let to the Austin Company. Standard Oil Company has begun moving to its larger new quarters in the Union Terminal Building, Cleveland.

Perfect Gas Conversion Process

A new British patent has been granted to Anglo Persian Oil Company, Ltd., Dr. A. E. Dunstan and R. V. Wheeler, for an invention relating to the utilization of natural gases, cracking unit gases, retort gases, and gases from unit for low temperature carbonization of solid carbonaceous substances, and generally to the treatment of gases containing gaseous paraffin hydrocarbons.

This patent or process has among its claims the obtaining of high yields of aromatic bodies in simple thermal treatment of gases under conditions where the production of free carbon is minimized and to produce residual gas that may be used for the production of carbon black, or for the production of other organic materials such as oxygenated derivitives of the hydrocarbons such as alcohols, aldehydes, ketones, organic acids and the like. According to the invention hydrocarbon gases with oxygen added are heated passed through tubes, or reaction chambers, issuing into an expansion chamber and suddenly cooled. Steam may be used, and nickel powder as a catalyst. The thermal treatment of the gas may be carried out by the use of nickel power in the reaction tube or any other catalyst. The temperature of the thermal treatment in the reaction tubes may be for example from 650° to 975° C. according to the composition of the gas used, but the treatment may be carried out at lower temperatures or at ordinary atmospheric pressures, or at all medium or high pressures.

In carrying the invention into effect, by way of example, a natural gas mixed with carbon dioxide was passed through a tube heated to from 600° to 700° C. the tube containing nickel powder obtained by reduction from the carbonate, and appreciable quantity of benzine was obtained as well as a residual gas adapted for utilization in the preparation of carbon black or alcohols, aldehydes, ketones, organic acids and the like, according to Petroleum Times. First application and prior to this, was No. 26719, dated October 8, 1927.

Increase Plant Capacity

Texas-American Syndicate's natural gasoline plant located south of Goldsboro, Coleman County, Texas, has been increased in capacity to 6000 gallons daily. This plant made its initial run April 10, 1930, and is operating on high pressure gas development by the company. It has equipment to handle 12,000,000 cubic feet of gas daily with an average recovery of approximately .6 gallon per 1000 cubic feet. Jackson Engineering Corporation built the plant on contract with H. T. Owen, Fort Worth, supervising the work for Texas-American Syndicate. Allen Wiseman, Goldsboro, is assistant in charge of operation.

McGraw-Hill Book Company, Inc., 370 Seventh avenue, New York, has just issued "Piping Handbook," by J. H. Walker, superintendent of central heating, the Detroit Edison Company, and Sabin Croker, also of the Detroit Edison Company. Price is $5.

This book makes available a comprehensive collection of authoritative data for the engineer interested in piping work in modern power plants, in distributing systems and in other industrial operations. Many sources have been drawn upon freely in order to assemble and coordinate all appropriate material.

Certain specialized subjects include: heat insulation, water supply piping, oil piping, and gas piping. These subjects have been prepared by contributors recognized as authorities in their respective fields. And many helpful definitions, formulas and tables are included.

Emil Geppelt, Jr., has resigned as assistant chief engineer for Graver Corporation, May 1, and has opened a private consulting engineer practice specializing in the design of pipe still distillation units. He is located at Laredo, Texas.

Massachusetts Institute of Technology is offering special courses in petroleum refining, planned particularly to meet the needs of young technical men in the petroleum industry, at the summer session which opens July 7 and terminates August 9. The courses are intended especially for men who, possessing an engineering and chemical background, may be seeking specialized training in the fundamentals of fluid dynamics, flow of heat, and the mechanism of interaction of phases.

Lee B. Mettler Company, 406 South Main Street, Los Angeles, has just issued a new catalog covering the Mettler line of gas burners, including the latest development of this company, the Mettler full automatic conversion burner. The Mettler entrained combustion principle of burning gas has been incorporated in the new conversion burner, making it possible to use primary air only for combustion.

A copy of this catalog will be sent upon request to the company.

Cuno Engineering Corporation, Meriden, Connecticut, has recently published a 20-page, loose-leaf, booklet which is devoted to the description and illustration of the Cuno Auto-Klean filters. A copy of this booklet will be furnished upon request to the headquarters of the corporation or to Dan T. Moore, 2702 Esperson building, Houston.

Republic Steel Corporation early in June received an order for 800 miles, or 50,000 tons of eight-inch electric welded steel pipe from Phillips Petroleum Company. This represents the first booking to be accepted by the corporation for its new electric welded pipe mill which will be placed in operation during June. Shipments on the order will start in July and will cover a period of approximately 10 weeks. This pipe goes into the construction of Phillips Petroleum Company's line for transportation of gasoline from Texas to Wichita, Kansas City, St. Louis and intermediate points. It will be the largest line ever laid for this purpose, the announcement states.

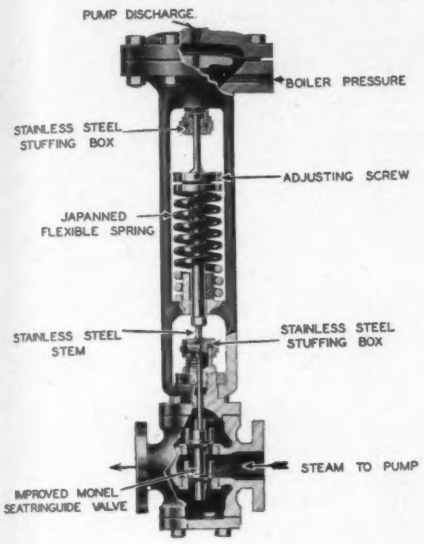
Shell Petroleum Corporation is starting construction work on a natural gasoline plant to be located on the north end of the Hobbs field, New Mexico, and prospects are bright for several other companies, including Amerada Petroleum Corporation and Humble Oil & Refining Company, to erect plants to utilize their own natural gas production. Shell Petroleum Corporation will build on its H. D. McKinley 320-acre lease, consisting of the north one-half of section 19-18s-38e, and will provide equipment for a daily output of 35,000 gallons.

C. F. Kolp, manager of the Waggoner Refining Company, which has a refinery and natural gasoline plant in Wilbarger County with headquarters at Electra, Texas, resigned effective June 1, and has been succeeded by W. T. Waggoner, Jr.

New Equipment for the Modern Plant

Pressure Pump Governor Viscosmeter

NEILAN, SCHUMACHER & CO.



Neilan, Schumacher & Company, 641-51 Santa Fe Avenue, Los Angeles, is now marketing a new advanced Neilan excess pressure pump governor, an illustration of which is shown here. This represents another addition to the Neilan line of automatic control and regulating devices.

It is fitted with improved "Seatringuide" valve in which the valve plug and seat rings are milled from Monel mental. This type of valve, by eliminating flow turbulence, reduces wire drawings.

Neilan governors are made of bronze, cast nickel-iron and chrome-alloy cast steel for pump discharge pressures up to 600 pounds. In the new Neilan line is found the results of several years of research and manufacture of sensitive control devices for the oil and gas industry.

Threader and Reamer

OSTER MANUFACTURING CO. AND WILLIAMS TOOL CORPORATION

Oster Manufacturing Company and Williams Tool Corporation, Cleveland, announce a new threader and reamer for small pipe, a new addition to the Oster-Williams line.

This new chip chaser reamer for one-eighth to three-quarters-inch pipe is announced together with the No. 001 chip chaser for one-half to one and one-quarter-inch pipe.

The No. 001 chip chaser is built on the same principle as the No. 00 chip chaser, and has the improved open type die head to allow an unusual chip clearance to facilitate oiling the pipe.

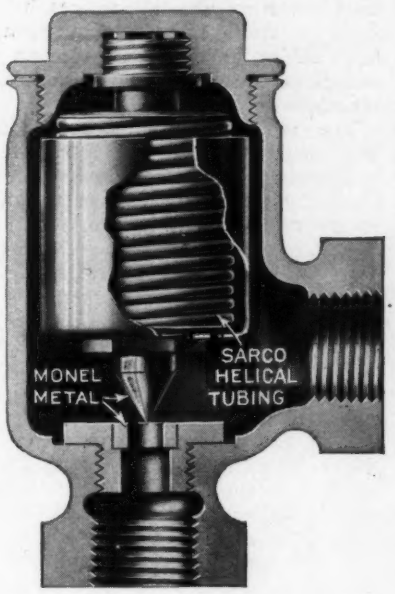
No. 001 has four die heads, including one-half, three-quarter, one, and one and one-quarter-inch, and has a ratchet handle. The ratchet is built into the handle out of the way, but is so placed that the operator may reverse the action of the ratchet or put it in neutral position, with an easy flick of the thumb.

The new chip chaser reamer fits the No. 00 chip chaser ratchet handle and has three reaming blades.

Further details are available upon request to the Cleveland plant.

Improved Steam Trap

SARCO COMPANY, INC.



Sarco Company, Inc., 183 Madison avenue, New York City, has announced three important improvements in the No. 9 steam trap following a long period of work by this company's engineering staff.

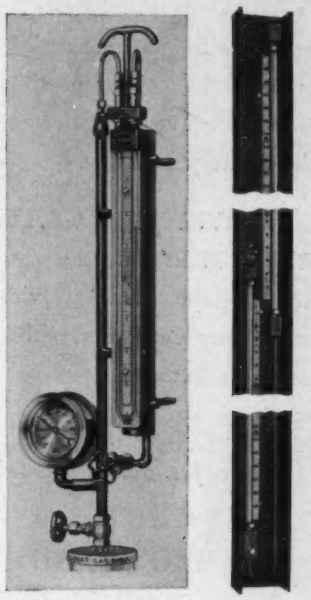
The trap now has longer bellows, four corrugations having been added to the bellows' helical tubing. This allows for the distribution of the element's movements over a total of 14 corrugations, minimizing its wear and adding to the life of the bellows.

There is a protective shielding, the thermo sensitive element now being surrounded by a heavy brass shield which protects it against damage by water hammer and keeps it clear of dirt, rust and other sediment of the steam lines.

The third improvement is the self centering valve heads. The new heads move more freely and under the pressure of the bellows center more perfectly in the seat. This feature is to insure a tightly closing valve to eliminate the possibility of "off center" valve heads, which would allow live steam to escape.

New Manometer

THE MERIAM COMPANY



The Meriam Company, Cleveland, Ohio, announces a special type of U-tube mercury column manometer designed to measure pressures up to 50 pounds per square inch, open to the atmosphere or complete vacuum. It is also suitable for measuring differentials on line pressures up to 500 pounds per square inch. Special construction is designed to eliminate the difficulty sometimes met in attaching large precision instruments of this kind to the connecting pipes.

Since the principle of a manometer depends upon the difference of liquid level in the two arms of the U-tube produced by the difference of pressure between the two ends of the tube, it is evident that the arms must in this case be about 10 inches high. In order to permit the manometer connecting union on the pressure side to be brought out at the middle instead of the top of the instrument, the upper part of one of the arms is omitted, and the pressure tube is connected to the usual gasket union to a point a little above the normal zero line of the liquid. The other arm of the tube, being open to atmosphere, needs no pipe attachment.

More complete details on this special type manometer is available by writing to the Meriam Company's headquarters.

New Control Device

GENERAL ELECTRIC COMPANY

General Electric Company, Schenectady, New York, announces a new device for controlling the operation of industrial machinery by the interruption of a beam of light. It is a photo-electric relay, essentially a vacuum tube device, and uses both the photo-electric tube and the pliotron.

It is designed to control industrial

Refinery equipment today requires large quantities of grating and treads.

ARROWHEAD has kept apace with the increasing demand and furnishes grating and treads for every requirement in the refinery industry.

ARROWHEAD GRATING AND TREADS are strong, non-slippable and serviceable under any condition, either interior or exterior.

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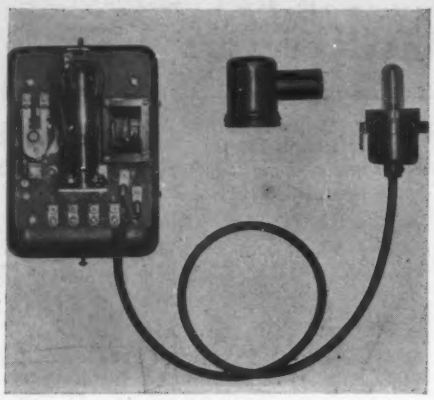

operations in which a change of light is involved. A machine which travels in a certain direction for a certain distance and is then stopped or reversed, is given as a typical application. When the traveling mechanism reaches its limit it would interrupt a beam of light falling on the photo-electric tube and thus cause the control device to function.

The new relay bears the General Electric designation CR-7505-A-1. It is designed for use in controlling an electric circuit in response to an increase or decrease in the amount of light falling on the photo-electric tube. The company lists the following advantages resulting from its use:

1. It operates without shock or resistance to the progress or movement of the object which actuates it, or without impairing the accuracy of delicate mechanisms.
2. It can be located remotely from the equipment controlled, thus permitting mounting in small spaces around automatic machinery.
3. It is adjustable in sensitivity.
4. It can be used outdoors by mounting in a watertight enclosing case.
5. It is easily installed, and its operation is easily adjusted or changed.
6. It can be operated at high speeds, 100 times a minute being an approximate maximum.

For some applications it may be necessary to select carefully a suitable light source and optical accessories, but for many cases the light source may be a domestic Mazda lamp with or without a simple reflector and shield.

The standard electric supply for the relay is 110/120 volts, 60 cycles, alternating current. The device may, however, be built on demand for other frequencies or voltages, and a similar device for operation where only direct current is available can be obtained.

The operation of the relay is described technically as follows: With a voltage of proper polarity and magnitude applied between the two elements of the photo-electric tube, the current it passes is proportional to the amount of light shining on it. This current (of the order of a few micro-amperes) is amplified by a pliotron. The sensitive relay is connected in the plate circuit and is energized or de-energized in accordance with the amount of light on the photo-electric tube. The contacts of the relay control the coil circuit of the contactor. When the relay in the plate circuit of the amplifier is energized, it will first open its normally-closed contacts and then close the normally-open contacts. This relay, therefore, either makes or breaks the coil circuits of the contactor depending on how it is connected.

When the contactor is de-energized approximately ten watts is required by the device, and when the contactor is energized approximately 30 watts is required.

Viscosimetic

AMERICAN VISCOSIMETER CO.

American Viscosimeter Company has perfected an instrument which provides direct readings of kinematic viscosity of lubricants. The device is available in practically any capacity and can be employed to indicate condition of lubricants under operating conditions, and can be used in the laboratory in connection with a circulatory pump in securing direct reading of kinematic viscosity, when the instrument is calibrated in Saybolt seconds.

Referring to the sectional view of the instrument, oil enters at the top through "A," under a variable pump pressure "P 1," and passes through the valve into the regulating chamber formed at the top by the upper portion of the casing and at the bottom of the diaphragm.

When there is no flow of fluid through the instrument, the valve stem,

C. H. WHEELER

Surface Condensers
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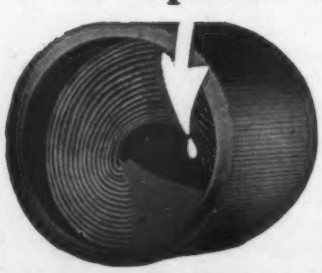
The Spiral Motion Is the Trick



That's why Hood's Chemico Spiral Packing Rings have been selected by so many engineers. The center hole prevents choking and clogging.

Made of acid-resisting shale—practically indestructible.

Used by all big producers because of the intensive movements.

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B. MIFFLIN HOOD CO., DAISY, TENN.

S & K Everdur Fittings Resist Corrosion

Try them in acid lines.

Bulletin 7E gives prices and corrosion data.

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The S & K line also includes jets, valves, condensers, oil burners, gear pumps, etc., for the oil industry

See our Air Pump ad on page 187

An exhaustive treatment of piping principles and practice

Piping Handbook

By J. H. WALKER

Superintendent of Central Heating, The Detroit Edison Company,
and
SABIN CROCKER
The Detroit Edison Company

764 pages, 5 x 8, illustrated, $5.00

The purpose of this book is to provide authoritative, and accessible data for the engineer interested in piping work. Every needed fact is given, covering scientific fundamentals, materials, and most effective methods.

This book is intended to make available to the engineer, contractor and designer a complete handbook of the data necessary to the most effective use of piping in its many and increasingly important industrial applications.

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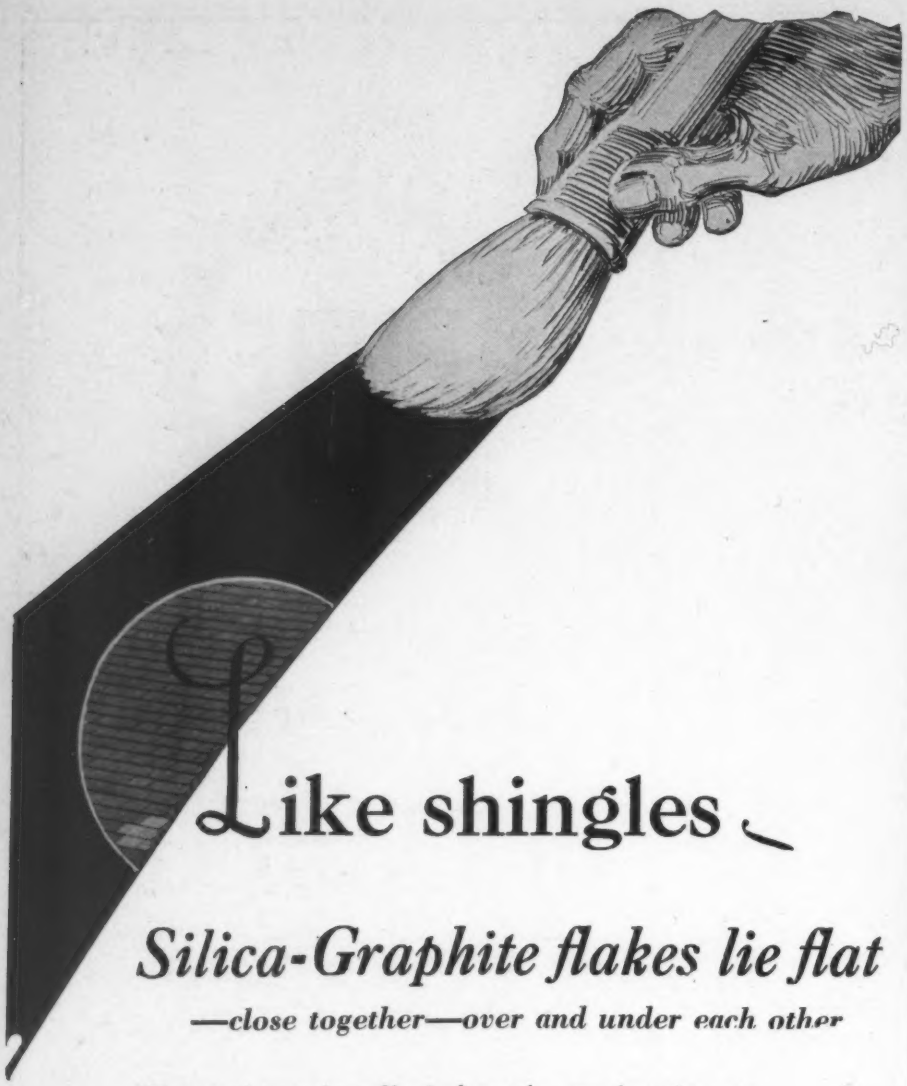

Like shingles

Silica-Graphite flakes lie flat

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Thus an impervious film is formed—one that gives entire protection to every inch of surface under it.

The pigment used in *Dixon's Silica-Graphite Paint* is flake graphite which is combined by nature with silica. The vehicle is boiled linseed oil. Every experienced paint maker knows that this combination provides the most satisfactory paint protection. Every user of *Dixon's Silica-Graphite Paint* knows this paint lowers their yearly painting costs by tenaciously clinging to and protecting surfaces to which it is applied in spite of moisture fumes, and other destructive conditions found in and about industrial plants.

You'll be interested in our booklet 99-B. It tells the full story of this remarkable protective paint.

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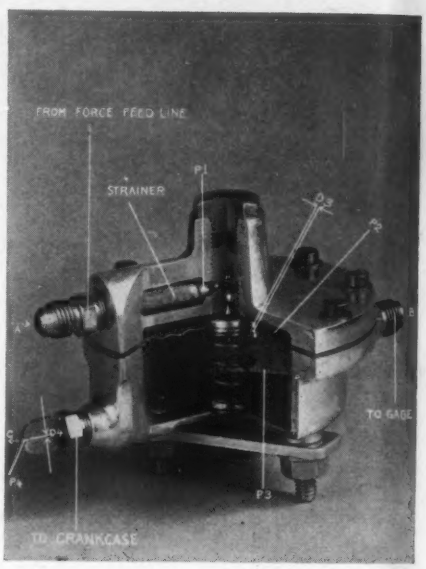
Adequate Protection at Minimum Ultimate Cost



a little point which is centered in the diaphragm, unseats the ball valve and opens the valve. The diaphragm has a sharp edge orifice of the diameter of D 3. The diaphragm is pressed down by the differential pressure P 2—P 3; P 2 being the oil pressure on the inside, and P 3 that outside the bellows.

The downward movement of the diaphragm, permits the ball to seat and close the valve. This downward pressure is balanced by the elastic force of the diaphgram and the upward pressure of the spring which is supported by the casing of the instrument. The pressure of the spring and the length of the valve are so proportioned that a predetermined pressure called P 5= P 2—P 3 is required to close the valve.

From the regulating chamber, which is formed as described above, the oil flows to the measuring chamber through the orifice D 3. The hydrostatic pressure, P 3, in this chamber is connected by the pressure gauge connected to outlet B. From the lower chamber the oil passes through a friction tube or capillary tube of the diameter of D 4. This diameter has small area relative to its length so there will be a streamline flow through it. This is further assured by rounding both the edge at the inlet and at the outlet from the tube.

When oil enters the instrument under sufficient pressure, P 1, the pressure difference P 5=P 2—P 3, will be

..When *any* refinery tube *fouls*..use a LIBERTY CLEANER

Hard, tough, scale or soft, sludgy, deposit—it all gives way to the Liberty Cleaner selected for the job. Sharp cutters, plenty of power, proper design, make a quick and thorough job of cleaning any tube or pipe that fouls.

Liberty Cleaners have for years been refinery favorites. They are built in all the sizes and types that refinery practice demands. Write for the catalog and get full data.

Liberty Tandem Type Cleaner with "S F" Cutting Head. Ideal for pressure stills.

Large diameter cleaner — built for tubes up to 12 in. O.D. Supplied for downtake pipes and tar lines.

Write us for bulletin and full details of LIBERTY CLEANERS designed to meet the needs of refinery tube cleaning.

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LIBERTY MANUFACTURING CO.
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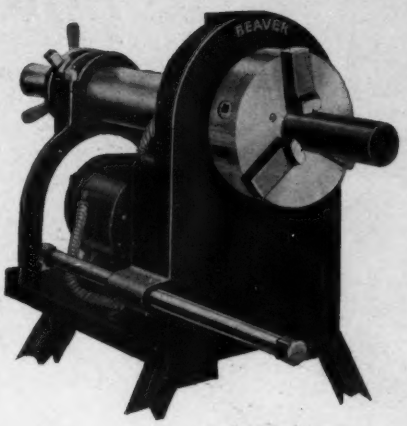
BEAVER POWER DRIVE



Profitable
Powerful
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Versatile

After All, This Machine May Be Better Suited To Your Needs

If you are considering the purchase of a "pipe machine" it may be worth hundreds of dollars to you to "take stock" of your actual needs. You may find, like hundreds of others, that the versatility and advantages of the Beaver Power Drive are better suited to your work than the limited capabilities of a different type of machine.

There's a very sound reason why every single Beaver Power Drive owner is well satisfied with his choice—and why additional Beaver Power Drives are bought when the volume of work justifies it.

The Beaver Power Drive cuts pipe, threads pipe and makes up fittings with any make of die stocks or pipe cutters. It is a sturdy machine. During the five years it has been on the market not one has called for repairs due to wear or inability of the machine to stand punishment. Think that fact over seriously if it's satisfaction and profit you seek.

It is a powerful machine fully capable of doing its work without faltering or stalling.

It is a simple machine—no frail parts or adjustments to suffer in the hands of even your most inexperienced workman.

Its range of usefulness is not limited to small sizes—leaving you to pay high prices to have the larger sizes cut and threaded outside your shop—or resort to expensive hand methods.

If you want to cut up to 12 inch and thread up to 6 inch then No. 44 (the slower machine) should be your choice. If you want to cut to 8 inch and thread up to 4 inch then buy the fast machine—the No. 45.

Bulletin "F" gives you full details—and it may prove to be most valuable reading to you.

Write for your copy.

THE BORDEN COMPANY
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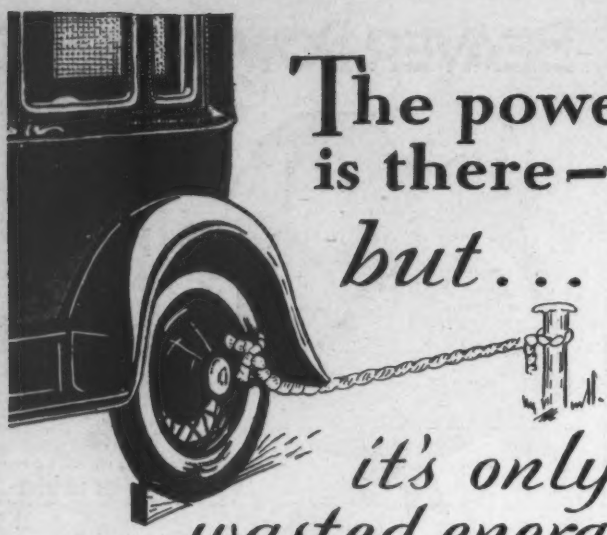


The power is there—

but...

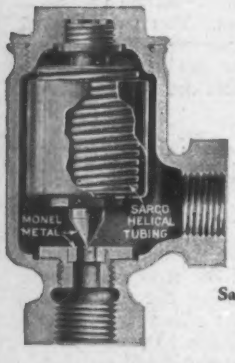
it's only wasted energy

There's power enough in your steam system but much of it is *wasted*—diverted to useless purpose—every time condensate gathers in pockets in the pipe line and contends for supremacy with oncoming steam. Water has no place in a steam line. The water always wins—turns more steam into water.

An occasional steam trap is not enough. *Every condensation point should be drained.* Sarco Steam Traps—only as big as a man's hand—make it possible to keep the whole line clean. Three Sarcos cost no more than one large trap. Yet each does its work perfectly, returning condensate to the hot well as fast as it forms.

Self-adjusting to any pressure from 0 to 100 lbs. No installation expense; just screw them into the pipe line and forget them. No platforms to build or pits to dig. Small enough to go anywhere. Won't air bind, wire draw or freeze. Can't leak live steam.

Use the coupon below and we will send you one for a 30-day free trial. The only way you can lose is to pass up this offer. Write for Booklet S-95.



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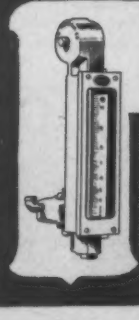


Flow Meters

THE MERIAM CO.

1954 West 112th St., Cleveland, Ohio

limited by the closing pressure of the valve. The velocity of the oil through the orifice, D 3, will vary substantially as the expression $\sqrt{P5}\sqrt{G}$, where P 5 is the differential pressure defined by the above equation and G is the constant of gravity. Since both P 5 and G are constant, the regular flow of oil into the lower chamber is constant. The oil must flow through the friction tube at the same rate as it flows out of the lower chamber. It is the law of capillary tubes that the rate of flow through them is directly proportional to the pressure drop and to the viscosity. Hence, if the rate of flow remains constant, the pressure drop—measured by the gauge M—must vary directly as the viscosity. The instrument measures directly kinemetic viscosity.

To cause the instrument to function, the pump pressure P 1, must attain a certain minimum value, which in present values is approximately 10 pounds. If the pressure in the regulating chambers is momentarily lowered, the spring will allow the valve to open, thus permitting an increased flow of fluid in the regulating chamber which will raise the pressure. The momentary pressure surge will close the valve tightly until sufficient oil has escaped through D 3 to reduce P 2 to normal. These oscillations are negligible as the spring is so adjusted that a change in pressure of only 1 per cent affects the opening of the valve considerably.

Further information can be secured from American Viscosimeter Company, 110 East 42 street, New York City.

Steam Control Equipment

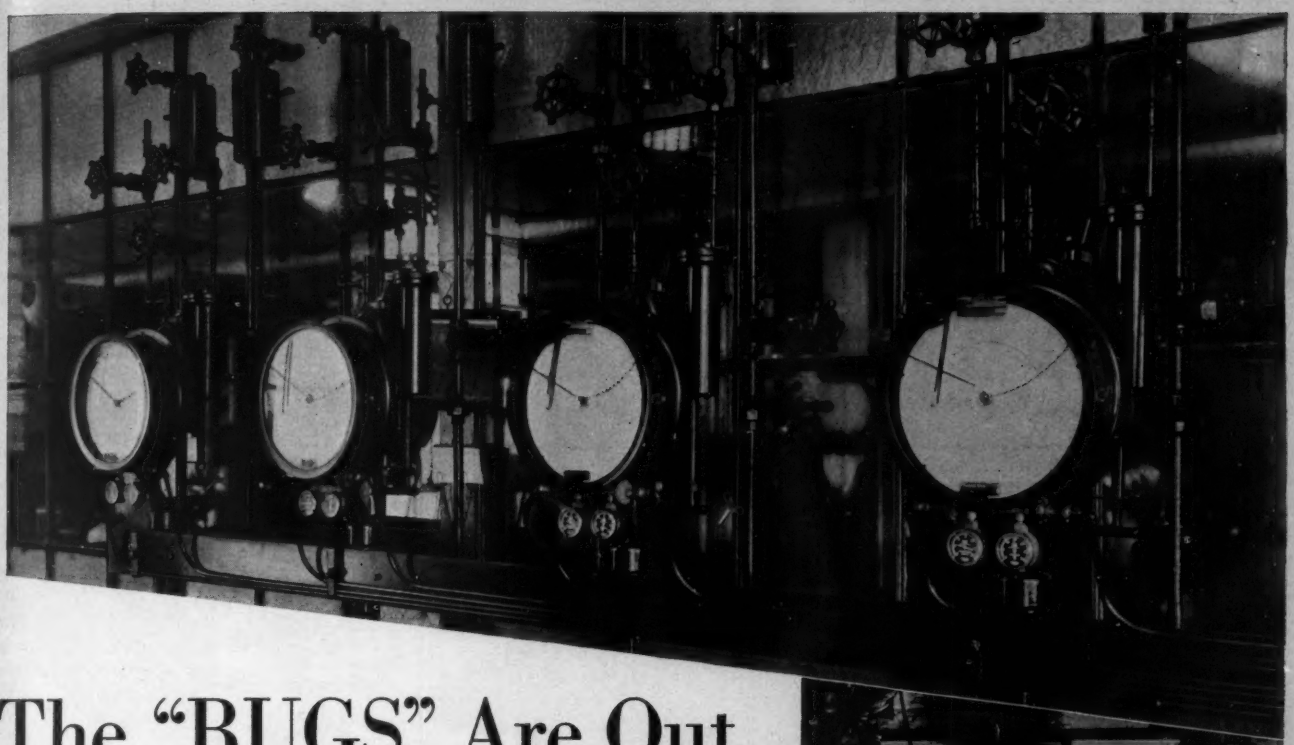
NEILAN SCHUMACHER AND COMPANY

Neilan, Schumacher & Company, Los Angeles manufacturers and distributors of engineering specialties, announce that final plans are being made for national distribution of the advanced Neilan steam control equipment.

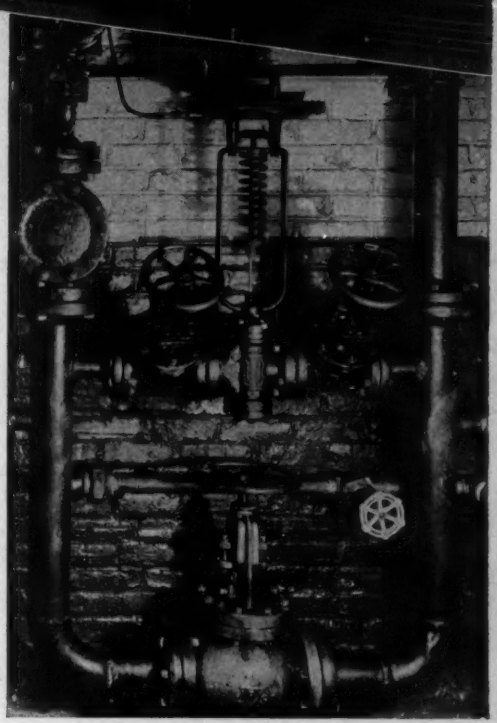
New features include such improvements as non-corrosive stainless steel valve stems and other parts, ball bearings, strong nickel-iron and chrome-alloy steel body castings, and the improved "Seatringuide" Valve to reduce wire-drawing.

Neilan steam line products include pump governors, reducing valves, auxiliary pilot operated float valves, steam traps and air traps and many other items. More specific information regarding these products may be obtained by addressing the company at 641 Santa Fe Avenue, Los Angeles.

Brown Instrument Company, Philadelphia, has issued an interesting and instructive booklet entitled "Applying Temperature Control to Oil Refining," by R. D. Bean, manager of engineering development. This booklet of 21 pages and five pages of illustrations of typical chart records, discusses the various temperature control problems encountered in refining practice, together with the types of control equipment available. It carries many interesting details without going into exhaustive



The "BUGS" Are Out



Over eleven hundred successful installations of Foxboro Flow Controllers prove this. They work—and with a minimum of attention. The experimenting stage was past six years ago. The experience gained during these years from hundreds of installations is yours for the asking.

Foxboro Flow Controllers have saved thousands of dollars and untold trouble for many refiners and producers, and *they can do it for you.*

They hold the control point *where you want it held* and accurately record the result. Look at the records on the Flow Controllers shown above! (They have not been retouched).

The responsibility behind a Foxboro Flow Controller is not divided. These Controllers are a hundred per cent Foxboro built and serviced.

Foxboro is the oldest maker of Orifice Flow Meters as well as of Recorder-Controllers and it again takes the lead in Control Engineering with its V-Port Controlled Valves. Correct Controlled Valves are half the story of Flow Control. Write today for Bulletin 167-L, "Foxboro V-Port Controlled Valves."

A few of the many Foxboro Flow Controllers used by one of the large Eastern Refineries—and one of the V-Port Controlled Valves.

On one refinery process Flow Controllers tripled production.

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INSTRUMENTS *for* CONTROLLING, RECORDING *and* INDICATING TEMPERATURE, FLOW, HUMIDITY *and* PRESSURE

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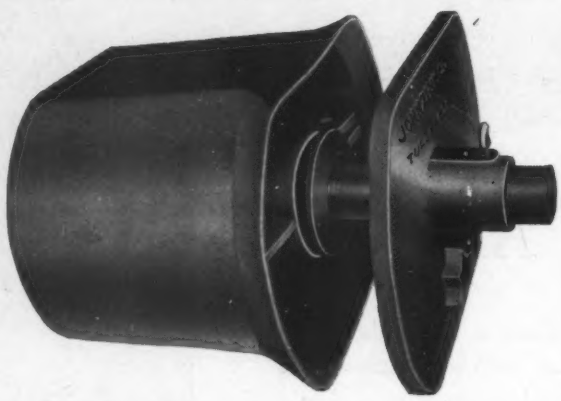
Short Flame Burners
Flameless Burners

Special Burner for Gasoline Plant and Refinery work.

Burns Rectifying column and Still gases with a short flame.



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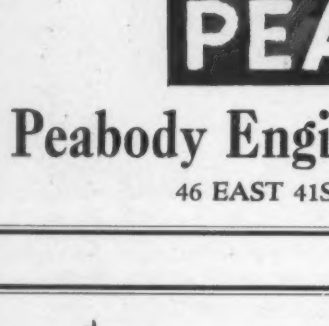

W. N. BEST High Pressure Oil Burner

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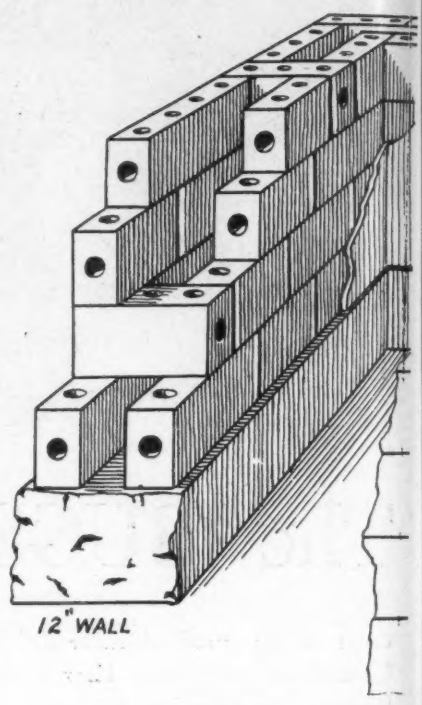
technicalities, and is of interest to both the practical man and technologist. Tower, furnace and hot oil control are discussed at some length. Copies of this booklet will be mailed upon request to The Brown Instrument Company, Wayne and Roberts Avenue, Philadelphia.



Interlocking Building Tile

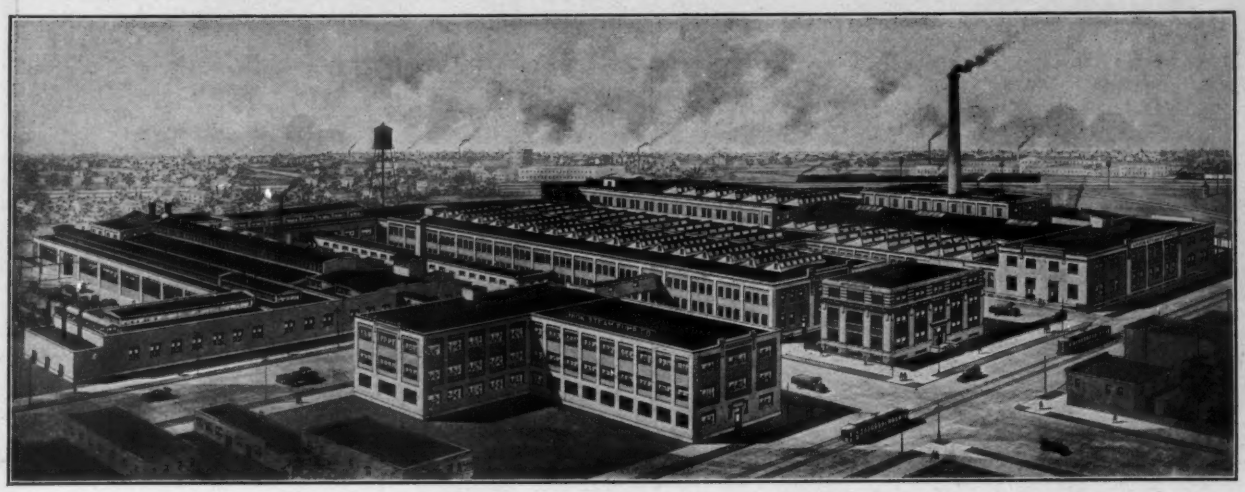
CENTURY MATERIAL BUILDERS

Century Material Builders, 717 Second National Bank building, Houston, has been organized to manufacture and distribute "Lay-More" interlocking building tile in the Houston territory following the closing of a deal recently with the Lay-More Tile Machine Company of Crawfordsville, Indiana.

In manufacturing this new type building tile, concrete is placed in a steel mould four by six by 16 inches through the center of which runs an expander tube. The mould is closed and 160 pounds compressed air pressure is applied, expanding from the center of the mix, thereby tamping the tile while green to absolute bond, reducing the voids to a minimum and insuring an accurate size and interlock.

The constituents of the mixture for the tile has been worked out after a long period of research. Features of the material are the lasting qualities and the fire-proof element. The method of interlocking serves to give strength to the finished structure through being doubly reinforced, eliminating possible shifting of position.

Century Material Builders is owned by Clyde Ellis of the Clyde Ellis Company, Houston and Ralph B. Cushman, who resigned in February from Republic Supply Company after 11 years of service with that organization. The company will develop the market for this new building material in filling station and refinery construction.



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By H. S. BELL, C. E.

Every detail of American refinery practice — the most up-to-date developments as well as the standard methods — are fully covered in this book. Vapor phase craking, the production of high compression gasoline, the development of modern pipe stills, the use of Diesel engines in oil pumping, and hundreds of other subjects of equal interest and importance, are discussed, covering in full every detail of oil refinery operation, engineering, and design.

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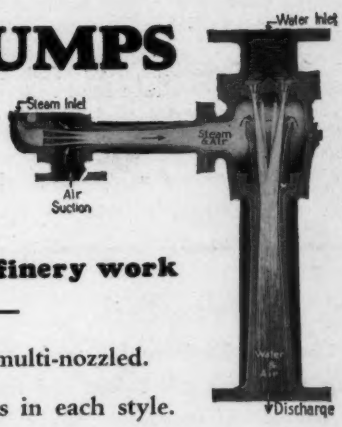

Use them in refinery work

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Five standard sizes in each style.

The S & K Hydro-Steam Air Pump pictured operates without inter- or after-condenser.

Bulletin 5-H has just been revised.

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PHILADELPHIA

See our Everdur ad on page 181

ITEMS ABOUT MANUFACTURERS

Bullard-Davis, Inc., a subsidiary of Davis Emergency Equipment Company, 67 Wall street, New York City, manufacturers and distributors of first aid and safety equipment, has announced that the Houston office is located at 720 Leeland avenue. H. C. Weigley is in charge of this office, assisted by J. B. Blakemore. Formerly the office has been jointly operated by Weigley, representing Bullard-Davis, Inc., the Delaware Company, with J. J. Delahide representing Bullard-Davis, Inc., (California), the latter being a separate corporation, acting as sales organization of the company in the Western States. This separate corporation is no longer connected with the Bullard-Davis, Inc., (Delaware) and the Davis Emergency Equipment Company, the announcement states.

Terry Steam Turbine Company, Hartford, Connecticut, has appointed S. O. Maxwell district manager of the New York office. He has been connected with this company since 1925, and during the past few years has been assistant to the New York manager.

Brown Instrument Company, Philadelphia headquarters, has just issued a revised edition of its electric flow meter instruction book. It is a 40-page book, fully illustrated, and explains the mechanism of the various types of Brown flow manometers, indicators, and recording instruments, as well as giving instructions for installing the equipment, adjusting the instruments for zero readings and changing range tubes.

Of special interest is the new low range manometer, Model 252, which is furnished for measuring the flow of gas or air where the pressure does not exceed 50 pounds per square inch. This manometer is described and pictured, together with the standard single and double range high pressure manometers. Practical suggestions for avoiding difficulties are given, and tables of correction factors for pressure, quality and superheat of steam are presented. Anyone interested will be mailed a copy of this book upon request to Brown Instrument Company's Philadelphia office.

Turbo-Mixer Corporation, New York City, manufacturers of agitating and allied equipment, announce the appointment of J. E. Moul as general manager. Moul's previous connection was that of president and general manager of Gifford-Wood Construction Company, New York.

Wanted

Chemical Engineer for work on heat exchanger calculations and the preparation of proposals. Applicant should have latent sales talent as position open has unusual possibilities. Familiarity with fractionating equipment will be of decided advantage. Give full particulars of education and experience, stating present salary, and include small recent photograph with first letter.

Struthers-Wells Company
Warren, Pa.

H. F. KNEEN

Lincoln Electric Company, Cleveland, has advanced Harold F. Kneen from assistant to plant superintendent. Kneen came to the company in June, 1929. His previous employment was with Indiana Flooring Company, Ironton, Ohio, as superintendent, and as heat transfer engineer for Ingersoll-Rand Company.

Kneen is a graduate of Cornell University, where he completed his course in industrial engineering in June, 1925.

Concurrent with the announcement of Kneen's advancement, Lincoln Electric Company announces the appointment of C. J. Bowers as production manager.

Butler Manufacturing Company has appointed Ralph B. Henno as Eastern and export representative with offices at 130 West 42nd Street, New York City. He has been with this organization since 1924, representing the chemical purification equipment division of the company in Connecticut, New York State, New Jersey and the Philadelphia territory. Under Henno the New York office is now being organized to handle the full line of Butler manufacture, including oil field storage, oil transportation equipment and steel buildings.

Edward Valve & Manufacturing Company has appointed Riffe & Thomas, Inc., successor to the W. A. Ross Company, Charleston, West Virginia, as its representative, with headquarters at Charleston.

Turbo-Mixer Corporation has leased considerably increased space in the Crystal Building, 250 West 43rd Street, New York City.

The new quarters permit consolidating under one roof the general offices as well as the testing and research laboratories.

At the same time production of Turbo equipment will be shifted to new facilities recently acquired at Hudson, New York, where all manufacturing operations will be handled in one plant.

Republic Steel Corporation, Youngstown, Ohio, will start large scale production of electric welded pipe at the company's new pipe mill, according to Tom M. Girdler, chairman of the board of directors. Completion of the mill is being rushed and all of the important equipment is in place with the exception of two large machines which are expected to be installed by the end of the current month.

This pipe will be produced under the Johnson patents, controlled by the company.

With the completion of the new production unit, Republic Steel Corporation will have two mills for making small pipe from two to eight inches in diameter, and one mill for making pipe from eight to 16 inches. Total capacity of the mills will approximate 30,000 tons annually.

Chicago Bridge & Iron Works has moved its Atlanta office to the Rhodes-Haverty building, R. H. Campbell is in charge.

Union Carbide & Carbon Corporation has completed its new building at 910 Baltimore Avenue, Kansas City, Missouri. This permits Union Carbide and Carbon Corporation to consolidate the Kansas City offices of its various units in one building so as to provide improved facilities for serving its customers in this district.

The units of the corporation now housed in the 11 story building include Linde Air Products Company, The Prest-O-Lite Company, Inc., Oxwell Acetylene Company and Union Carbide Sales Company. These companies manufacture and distribute a complete line for oxy-acetylene welding and cutting. In addition to having its district offices here Oxweld Acetylene Company will maintain an apparatus and supply stock in

Chemical Engineer

to take charge of Petroleum Oil Laboratory. This man should be thoroughly acquainted with refinery operation, including the testing of fractionating equipment. This position holds an exceptional future for the proper party. Give full particulars of education and experience, stating present salary, and include small recent photograph with first letter.

Struthers-Wells Company
Warren, Pa.

ENGINEER experienced in heat transfer equipment for oil refineries. Prefer man with practical experience as well as technical training. Location, Philadelphia. Address Box 6190, care Refiner and Natural Gasoline Manufacturer, Houston, Texas.

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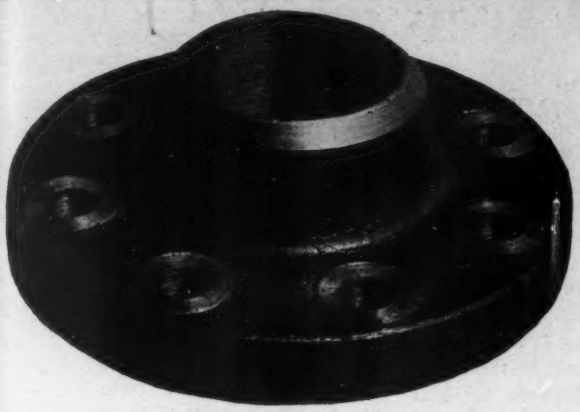

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SAVE TIME—REDUCE COSTS

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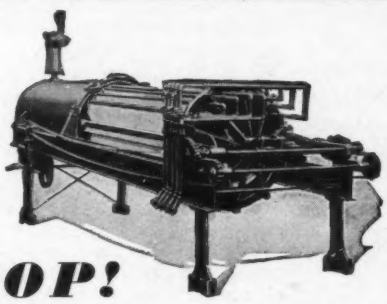

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—Think About Residuum

IS pressure still residuum a "waste" in your plant? What are you doing with it?

Several refineries are using our Kelly Pressure Filter to make their residuum marketable. It's costing them only a few cents a barrel, too.

Complete data covering this treatment can be obtained from our nearest office.

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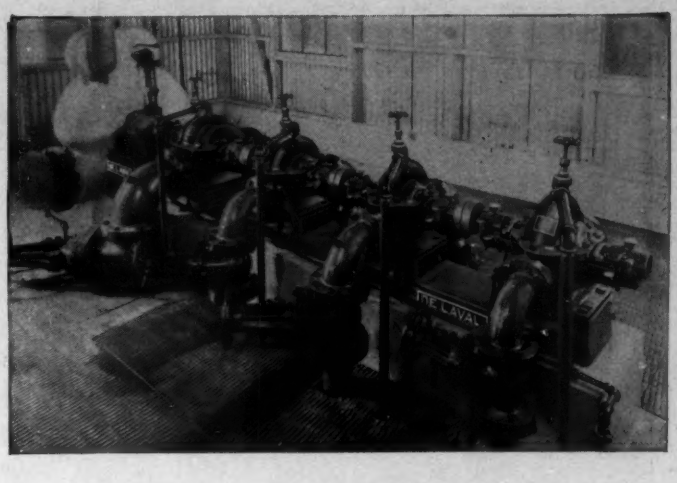

De Laval Pumps
for Absorption Plants

AS all pumps of an absorption unit operate together, they can be driven from a single turbine to advantage, as shown in this photograph. The De Laval velocity stage turbine runs at 2700 r.p.m. and drives an 8 in. pump supplying 1000 gals. per min. of water against 70 ft. head, a 2½ in. pump handling 185 gals. per min. of 0.81 specific gravity rich oil against 55 lbs. per sq. in., and a 2½ in. pump handling 60 gals. per min. of .8 specific gravity reflux gasoline, against 20 lbs. per sq. in. The same plant contains two other duplicate De Laval pumping units.

De Laval turbines and pumps are designed for continuous operation. All parts are made of the best materials, on a limit gage interchangeable basis, and parts subject to wear are readily renewed, as the replacement parts do not require to be fitted. All units are fully guaranteed as to efficiency, capacity, pressure and other characteristics, and are thoroughly tested before leaving our works.

De Laval
Steam Turbine Company
Trenton, New Jersey

Local Offices: Atlanta, Boston, Charlotte, Chicago, Cleveland, Duluth, Havana, Honolulu, Houston, Kansas City, Los Angeles, Montreal, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., St. Paul, Salt Lake City, San Francisco, Seattle, Spokane, Toronto, Vancouver,

3046

Manufacturers of Steam Turbines, Centrifugal Pumps, Centrifugal Blowers and Compressors, Flexible Couplings, Double Helical Speed Reducing Gears, Worm Gears, Hydraulic Turbines and Special Centrifugal Machinery.

An airplane view of part of a refining plant at Ponca City, Oklahoma, showing our cooling tower. This tower is 60 feet high.

Cooling Water From 150 Degrees to 74 Degrees

THE 70 degree wet bulb is the July average for Oklahoma. Our problem was to design a cooling tower which would cool water going on the tower at temperatures from 125 degrees to 150 degrees to a point within 5 degrees of the wet-bulb, cooling over a range as much as 75 degrees.

The solution to the problem was a cooling tower 60 feet high with twenty decks. That cooling tower was installed almost four years ago, and the results to date have been entirely satisfactory. Records have been kept of the daily and often hourly performance of this tower, and true wet-bulbs have been taken with a sling psychrometer as well as stationary wet-bulb readings, so that the performance of the tower has been checked in every way against the cooling results it was designed to accomplish.

Not every refining plant has a water cooling problem as hard as this. We cite this merely to show that our engineering department can handle difficult assignments when necessary. Ordinarily our Standard Type Cooling Towers will meet your requirements perfectly. They are described in our Bulletin 283-R, a copy of which will be sent on request.

THE COOLING TOWER COMPANY, INC.

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GASOLINE PLANT AND REFINERY CONSULTANTS	LABORATORIES MEDICAL ARTS BLDG. TEL. 4-4830	FRACTIONAL DISTILLATION ANALYSIS

the basement of the building. Other units of the corporation, J. B. Colt Company, manufacturer of farm and home acetylene lighting and cooking equipment and National Carbon Company, Inc., national distributor of Eveready products will also maintain Kansas City offices in the building.

Peabody Engineering Corporation, manufacturers of fuel burning equipment, whose office for the past eight years has been in the Bowery Savings Bank building at 110 East 42 street, has moved to new quarters which are leased for a period of 10 years. The company will occupy the entire 39th floor of the Lefcourt Colonial building on the southeast corner of 41 street and Madison avenue. An increased volume of business and additions to the staff have made it necessary to take over these large accommodations for the home office.

The company has branch offices in all the larger cities in the United States, and is represented in Great Britain by Peabody Limited, a subsidiary company.

Brown Instrument Company, Philadelphia, has just let a contract for 40,000 square feet of additional floor space to the Robert E. Lamb Company, representing the third expansion program within the past three years. Construction will be started shortly, and the new space will be occupied early this fall. This extra space will be in the form of two additional floors on all of the new two-story concrete sections of the plant.

Wilkinson Controller Company, 5700 Santa Fe Avenue, Los Angeles, has opened a branch factory and office at 436 Merchants and Manufacturers Building, Houston.

This company manufactures and distributes the Wilco duplex tank controlls for regulating pressure on storage tanks, flow tanks and rundown tanks during periods of loading and unloading, and the expansion or contraction of gas in the tank. The Wilco duplex relief valve is another product of the line of regulator equipment of this company.

P. H. Wilkinson, president of the company, opened the Houston office May 15, and is managing the office with R. Drummond as assistant manager. The territory covered by this office will include Texas and Louisiana. The Houston factory will serve as an assembly plant, where a line of the company's equipment will be on display, ready for shipment.

Wilkinson regulator equipment is used for taking wet gas off of tanks for the removal of gasoline in an absorption plant and for returning the tail gas through the Wilco duplex relief valve into the tanks.

Neilan, Schumacher & Company, manufacturers of control equipment, is building a new and larger experimental laboratory at the factory, located at 641-651 Santa Fe Avenue, Los Angeles.

When the new laboratory is finished and equipped, the company's present modern laboratory will be used only for testing and adjusting control equipment prior to shipment, it is understood, and the new laboratory, now nearing completion, will be used exclusively for experimental research and development. Neilan control equipment is thoroughly tested throughout its pressure range, under actual working conditions and by engineers, before being shipped from the factory.

Republic Steel Corporation has started operations in the new stainless steel finishing division, according to an announcement by T. M. Girdler, chairman of the board of directors. The new equipment, located at Massillon, gives the company greatly increased capacity for the production of highly polished stainless sheets. The metal is produced under Krupp license.

The equipment consists of 40 units, specially

One hour later this truck looked new!

OAKITE makes light work of cleaning dirty tank trucks. And those belonging to one southern refinery were *dirty*—so completely covered with a gasoline and oil scum that before cleaning, it was impossible to tell what colors they were painted. Even their red lettering, once strikingly evident, was unreadable.

But an hour after the Oakite solution had been applied to the first truck, its colors again stood out clear and bright, almost like new. And the paint was not affected in the slightest.

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*Stocks of Oakite materials are carried in these cities.

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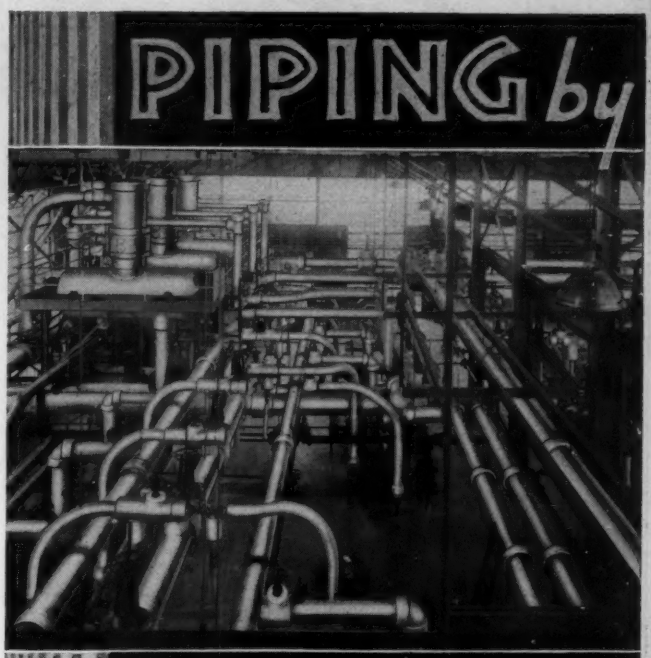

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To meet the ever-increasing requirements of this rapidly growing industry and to keep pace with the latest scientific achievements, refineries require the most modern equipment and give strict attention to maintenance and upkeep. Their demands are exacting—but it is a tribute to this organization that "POWER PIPING" has met their needs efficiently and economically through the years!

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FROM A MERE FITTING TO A COMPLETE SYSTEM

For cracking process in oil refineries we furnish Aluminum Armored Asbestos filled Gaskets and Corrugated Armco Iron or Monel Metal Asbestos encased.

Copper rings 3/16" thick for 4 and 5" O. D. tubing.

Washers or gaskets made of Aluminum, Copper and other Metals.

Write for Prices.

METALLO GASKET CO.

NEW BRUNSWICK, N. J.

The Watermelon Type →

This type controls steam flow through two delivery points simultaneously and proportionately. It records the flow rate on charts. It also gives direct visual readings. It does all of these things simultaneously. Full information on request.

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Steam Flow Controllers for Oil Stills

Whatever your steam control problems may be, place them in the hands of our engineers for solution. Scientific steam flow control for oil refineries is our specialty.

Pumpkinseed Type →

This type is recommended for smaller rates of flow. It, as well as the Watermelon Type, is sometimes furnished with a recorder.

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Manufacturers of the TAR BABY BURNER, to handle Fuel Oils, Water Gas Tar, Acid Sludge and Residue Fuels.

Without obligating us in any way, please send information on ( ) the Watermelon Type of Steam Control for Oil Stills; ( ) the Pumpkinseed Type; ( ) the Tar Baby Oil Burner.

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designed by company engineers. Rough grinding, polishing and buffing operations are carried on in separate rooms so that no grit in the air may mar the final finish. In securing the mirror finish new oscillating type machines are used which eliminate all polishing marks.

According to Republic Steel Corporation officials, the development of machinery for quantity polishing of Enduro Nirosta stainless steel largely solves the problem of its production on a volume basis in this country.

Maintenance Engineering Corporation, Houston, has announced the appointment of M. N. Aitken as sales engineer, effective June 1, 1930, to assist in promotion of the more technical specialties for refineries, pipe lines and power plants, handled by the Maintenance.

Mr. Aitken is a graduate of the Rice Institute engineering department and for a period of time has been connected with the engineering department of Shell Petroleum Corporation. His experience as well as his wide acquaintance in the industry have especially fitted him for the duties of his new connection.

Chicago Bridge & Iron Works has opened a new office in Houston, Texas, in the Electric Building, in charge of J. R. Donaldson, who was formerly in the company's Dallas office.

Maintenance Engineering Corporation, Houston, announces the opening on June 1 of an office and branch warehouse at Fort Worth in charge of M. A. Hart. According to W. J. Peddie, president of the corporation, the purpose of the new branch is to make stocks more readily available for the North and West Texas territory. Hart, who has been with the company in Houston for the past two years, will cover the territory around Fort Worth and further west.

Principal stocks carried in Fort Worth will consist of forged steel valves, fittings, flanges, tube-turns, cast steel gate valves and cast steel flanged fittings. The company handles refinery, pipe line and power plant specialties and have had a marked growth in the past few years. The new Fort Worth office and stocks will be at 500 East 9th Street.

Officers of the Maintenance Engineering Corporation are W. J. Peddie, president, L. J. Burda, general manager, W. B. Rawson, sales engineer.

Boiler Engnieering Company, 24 Commerce street, Newark, New Jersey, has published a bulletin titled "How BECO Baffles Modernize Old and New Water Tube Boilers." Numerous illustrations show how to baffle correctly all types of water tube boilers, horizontal and bent tube. Charts are used to show the fuel saving through use of BECO baffles. Old boilers may be equipped with BECO boilers on the job.

General Electric Company, Schenectady, New York, has just issued the Industrial Control catalog, GEA-606B, 1930 edition, covering 220 pages. Descriptions, with illustrations, and operating methods are completely outlined on the alternating and direct current hand starters, speed regulators, drum switches and resistors, and magnetic controllers, and accessories, rheostats and resistors, limit switches are covered as are solenoids, solenoid valves, and brakes.

The company has issued a loose-leaf booklet of prices on fabroil gears and a price list on non-metallic gears and blanks. Loose-leaf sheets for insertion in the General Electric bulletin files have been issued on the CR9440-LS415 hatchway limit switch for control circuits, the general-purpose synchronous motors and the CR3100 drum controllers.

Any of this literature is available upon request to the Shenectady headquarters.